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The head-capsule and mouth-parts
of diptera

THE HEAD-CAPSULE AND MOUTH-PARTS
OF DIPTERA

BY

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPER-
VISION BY Alvah PetersonENTITLED The Head-capsule and Mouth-parts of DipteraBE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE
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on

Final Examination*

*Required for doctor's degree but not for master's.

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UNIVERSITY OF ILLINOIS
THE GRADUATE SCHOOL

May 21

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPER-

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ENTITLED THE RESEARCH AND DEVELOPMENT OF A

BE ACCEPTED AS FULFILLING PART OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF SCIENCE

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Required for degree but not for honor

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The head and mouth-parts of Diptera offer a rich field for research. A number of excellent studies have been made by several investigators and they deserve careful consideration. A review of practically all the literature shows that a majority of the workers have examined only one or a very few species. Meinert (1881) and Hansen (1883), however, studied a number of forms but they were mostly specialized species while an important study by Kellogg (1899) deals only with the families of the Nemotocera. Becher (1882) is the only investigator who has studied a large series of generalized and specialized species. A special effort has been made to secure as many generalized and specialized species as possible since it is highly desirable and essential in homologizing structures to have at hand a wide range of species.

Extensive studies have not been made, so far as known, on the head-capsule; consequently the important relationship which exists between the mouth-parts and the head-capsule in generalized insects has not been observed in Diptera. This relationship is just as significant in ascertaining the correct interpretation of the mouth-parts of Diptera as it is in other orders. The importance of this relationship is illustrated by a study of the head and mouth-parts of the Thysanoptera, Peterson(1915). The above deficiencies in the various investigations, so far as they relate to the number of forms studied and the homologizing of parts, justifies a more careful study of the head-capsule and mouth-parts of Diptera.

A review of the literature, Dimmock (1881) or Hansen (1883),

discloses the many and varied interpretations that have been given to the mouth-parts of Diptera. To ascertain the correct interpretation of the fixed and movable parts of the head, the head-capsule and mouth-parts of all the species studied, irrespective of their established systematic position, have been carefully compared with the head and mouth-parts of generalized insects. On the basis of this comparison, generalized, hypothetical types have been formulated for each fixed and movable part. Each hypothetical type is an accumulation of all the generalized characters found among the Diptera and should show an intermediate stage between generalized insects and Diptera. The use of such an hypothetical type is a great aid in showing not only how the dipterous type has been developed but also of great value in determining the homology of the parts.

The scope of this investigation makes it necessary to limit the discussions to the general subject of homology. Many details of structure and other interesting modifications, shown in the figures, which have no direct bearing on the subject of homology, have had to be omitted. The fixed and various movable parts of the head have been discussed separately and developed from hypothetical types; the discussion in every case proceeding from the generalized to the specialized.

All the general conclusions pertaining to the head and mouth-parts presented in the following pages are based entirely on a study of the forms listed under materials unless otherwise stated. General statements in respect to the mouth-parts are true only for species having them well developed.

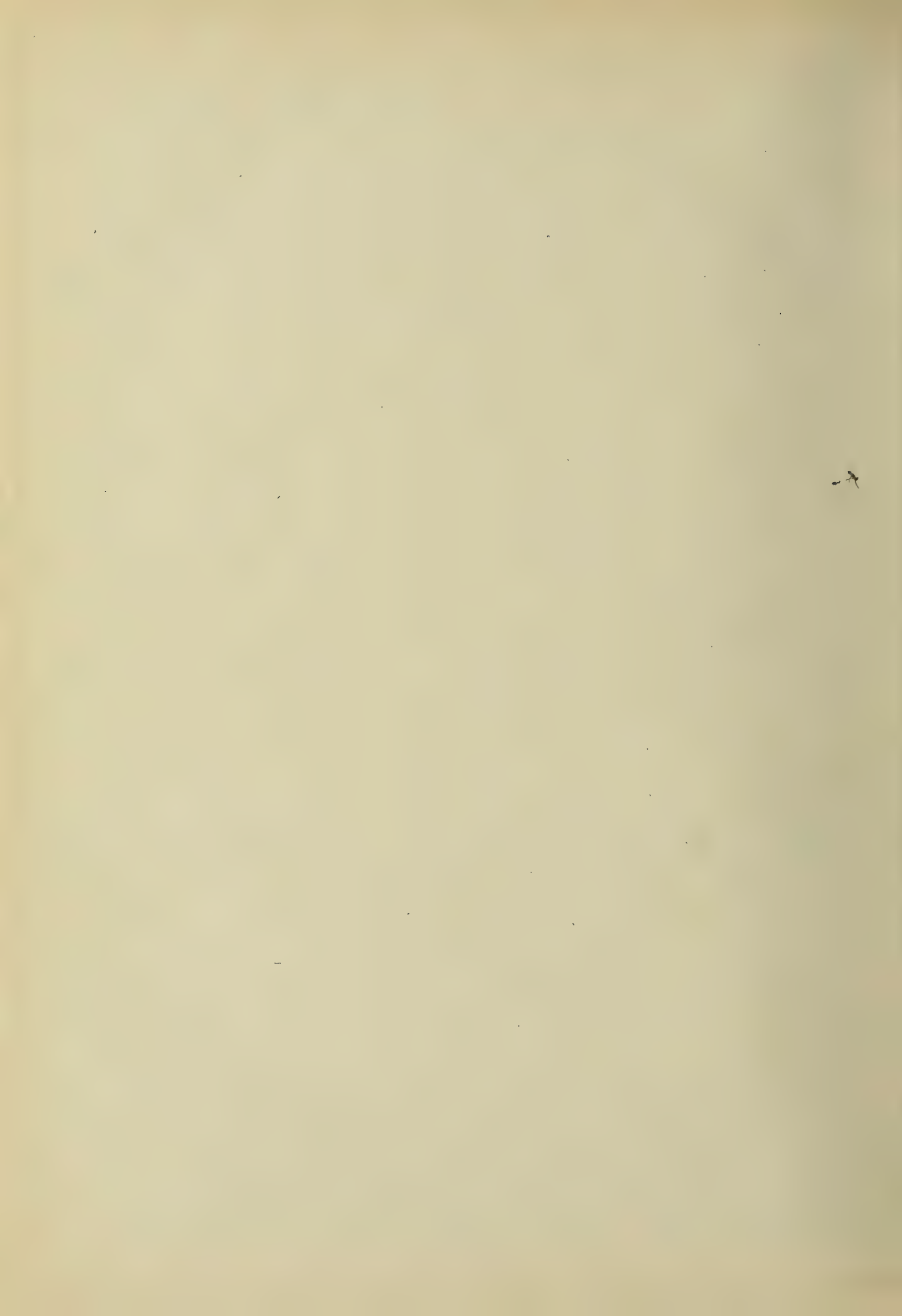
The names here adopted for the sclerites of the head and

mouth-parts have been made to agree, so far as possible, with^{4.} the terms now in common use for the same parts in generalized insects. The terms in most common use thruout the literature for structures peculiar to this order have been adopted unless they are otherwise unsuitable. New terms have been applied only to the structures described here for the first time and to the parts where the names now in use are inappropriate.

II. METHODS.

The greater part of this study was made from dried specimens that had been soaked from two to twenty-four hours in a ten per cent solution of potassium hydroxide. The sclerites of weakly chitinized forms show more clearly when they have been soaked for only a short time. After soaking, the heads were washed in distilled water to remove the potassium hydroxide and then preserved in seventy per cent. alcohol.

All dissections were made under a binocular microscope in seventy per cent. alcohol in deep watch glasses or in carbol-aniline oil. Studies and figures were largely made from the dissected parts in alcohol. Cleared preparations mounted in balsam were also found useful. In making such preparations the parts were dissected, stained and cleared in carbol-aniline oil. This oil evaporates slowly, will readily mix with safranin or orange G dissolved in ninety-five per cent alcohol, and will clear from any grade of alcohol above fifty per cent. The staining of material before mounting with safranin proved to be very useful in differentiating the almost colorless parts of some species. When using aniline-oil it is necessary to remove as much as



possible of the oil before mounting, otherwise the balsam will eventually darken.

The material for sections was fixed with hot (80 C.) corrosive sublimate (saturated corrosive sublimate in 35 per cent alcohol plus 2 per cent. of glacial acetic acid) for fifteen minutes to two hours, which was replaced by 70 per cent alcohol containing a few drops of iodine, and allowed to remain in this for twenty-four or more hours. Paraffin having a melting point of 62-64 C. gave a sufficiently firm medium in which to cut sections as thin as eight microns. Specimens stained in toto gave the best results, Delafield's haematoxylin requiring from 24-48 hours and Borax carmine 3-7 days

III. ACKNOWLEDGMENTS.

This investigation was carried on under the supervision of Dr. A. D. MacGillivray and to him I am greatly indebted for the sincere interest shown and the many valuable suggestions received. Many specimens, unobtainable in this vicinity, were secured from the collections of the Illinois State Laboratory of Natural History and for these I am indebted to Professor S. A. Forbes. I am indebted to the Graduate School of the University of Illinois for funds used in purchasing specimens. I am also indebted to Mr. J. R. Malloch of the Illinois State Laboratory of Natural History for the identification of all my material and for specimens and many suggestions; to Mr. J. M. Aldrich for species of Diopsidae, Phycodromidae and Blepharoceridae; to Mr. O. S. Westcott for a species of Phycodromidae; to Dr. P.S. Welch for a species of Simuliidae and to Dr. O. A. Johannsen for species of Dixidae and Blepharoceridae. I am also indebted to the many others who furnished me with unnamed material.

IV. MATERIALS.

The following list of Diptera includes all of the identified forms studied. The families, to which these species belong, are arranged according to Aldrich's Catalogue of North American Diptera. The generic and specific names of all but a few species may likewise be found in Aldrich's catalogue.

Aldrich lists ^{fifty-nine}~~sixty~~ families; of these, one or more representatives have been studied of fifty-three families. The following ^{six}~~seven~~ are not represented, ^{ph}Ornephelidae, Acanthomeridae, Nemestrinidae, Apioceridae, ~~Lonchaeidae~~, Rhopalomeridae, and Mycterbiidae. The male and female of each species figured have been observed except in a few cases. Species with the terms male or female after them indicates that this sex only has been seen. Both the male and female parts have been drawn when they were decidedly different. Where the two sexes are similar the figures were mostly made from the female. An asterisk before the name of a species indicates that this form has been embedded, sectioned and studied. The numbers following the various species refer to the drawings made of the same.

Suborder-Proboscidae.

Orthorhapha- Nemocera.

Tipulidae.-*Tipula bicornis, Fig. 18, 95, 178, 277, 383-4, 388 and 503., Tipula ⁴~~canctans~~, Tipula abdominalis, Limnobia imatura, female, Fig. 93, 386, and 507, Melobia punctipennis, female, Fig. 385, Trichocera bimacula, male, Fig. 16, 78, 158, 200, 260, 311, 365, 499 and 500, Geranomyia canadensis, male, Fig. 382 and 506. ⁴~~Pt~~choptera rufocincta, Fig. 15, Bittacomor-

pha, clavipes, male, Fig. 85 and 389.

Dixidae.- *Dixa clavata*, Fig. 19, 79, 163, 199, 262, 375, 387, 501 and 502, *Dixa modesta*, Fig. 254.

Psychodidae.- *Psychoda albipennis*, Fig. 8, 82, 166, 202, 263, 318, 372 and 529-30, *Psychoda* sp.

Chironomidae.- *Chironomus ferrugineovittatus*, Fig. 12, 88-9, 152, 206-7, 270, 312, 371, and 531-2, *Culicoides sanguisugus*, Fig. 253, 265 and 521, *Forcipomyia cilipes*.

Culicidae.- *Psorophora ciliata*, Fig. 10-1, 96, 159, 210-11, 251, 266, 373, 380-81, and 504-5, *Anopheles* sp., *Culex* sp.

Mycetophilidae.- *Sciara varians*, Fig. 17, 81, 150, 205, 267, 314, 360, and 512-13, *Mycetobia divergens*, Fig. 7, 90 and 161, *Mycetophila punctata*, Fig. 87. *Leia oblectabilis*, Fig. 368.

Cecidomyiidae.- *Rhabdophaga strobiloides*, Fig. 6, 86, 170, 201, 268, 313, 367, and 510-11, *Cecidomyia* sp.

Bibionidae.- *Biblio femoratus*, Fig. 13, 14, 91, 92, 153-4, 208, 264, 315, 364, and 522-23, *Biblio albipennis* sp.

Simuliidae.- *Simulium venustum*, female, Fig. 2, 77, 144, 204, 250, 258, 316, 366, 489, and 497-98, *Simulium Johanseni*, Fig. 3 and 252, *Simulium pecuarum*, *Simulium Jenningsi*.

Blepharoceridae.- *Bibliocephala elegantula*, Fig. 4, 5, 76, 83, 155-6, 203, 256, 269. 399 and 526-27, *Blepharocera* sp?.

Rhyphidae.- *Rhyphus punctatus*, Fig. 9, 80, 157, 209, 261, 321, 374, and 508-09.

Orthorhapha- Brachycera.

Stratiomyidae.- *Stratiomyia apicula*, Fig. 27, 28, 104, 160, 213, 273, 331, 395-96, and 545-46, *Stratiomyia meigenii*.

Tabanidae.- *Tabanus giganteus*, Fig. 20, 74, 75, 142-43, 214, 255,

259, 283, 317, 390-92, and 494-96, *Tabanus sulcifrons*, *Tabanus atratus*, *Tabanus trimaculata* and *Chrysops striatus*.

Leptidae.- *Leptis vertebrata*, Fig. 34, 35, 103, 145, 218, 275, 323, 369-70, 520 and 525, *Chrysopila proxima*, *Chrysopila thoracica*, *Chrysopila quadrata* and *Chrysopila velutina*.

Cyrtidae.- *Oncodes costatus*, Fig. 53, 105, 109, 220, 486 and 487.

Pterodontia flavipes.

Bombyliidae.- *Exoprosopa fasciata*, Fig. 29, 98, 162, 216, 285, 361, 426-29, and 549-50, *Systoechus vulgaris*, *Lepidophora* sp?.

Therevidae.- *Psilocephala haemorrhoidalis*, Fig. 33, 36, 100, 173, 281, 324, 402-03, and 533-34.

Scenopinidae.- *Scenopinus fenestralis*, Fig. 41, 42, 107, 149, 219, 282, 325, 400-01, and 537-38.

Mydidae.- *Mydas clavatus*, Fig. 30, 99, 146, 271, 319, 397-98, and 535-536.

Asilidae.- *Promachus vertebratus*, Fig. 22, 84, 147, 148, 217, 276, 322, 376-79, and 517-19, *Asilus notatus*, *Deromyia umbrina*.

Dolichopodidae.- *Dolichopus refractus*, Fig. 43, 112, 168, 226, 284, 432-34, 524 and 528, *Dolichopus* sp?, Fig. 108, *Psilodinus^{po} siphon*, *Sympycnus lineatus*.

Empididae.- **Empis clausa*, Fig. 26, 40, 97, 164, 215, 274, 352, 421-3, and 547-48, *Rhamphomyia glabra*, Fig. 424-25, *Euhabus* sp?.

Lonchopteridae.- *Lonchoptera lutea*, female, Fig. 37, 102, 177, 223, 280, 320, 406-08, 539, and 541.

Phoridae.- *Aphiochaeta agarici*, Fig. 31, 111, 174, 224, 278, 335, 393-94, 540, and 544, *Metopina* sp?, *Dohrniphora confinna*.

Cyclorhapha- Athericera.

Platypezidae.- *Platypeza velutina*, Fig. 32, 110, 165, 222, 272, 326, 415-16, and 542-43.

Pipunculidae.- *Pipunculus cingulatus*, Fig. 38, 39. 106, 151, 243, 279, 327, 435-36, and 561-62.

Syrphidae.- *Eristalis tenax*, Fig. 23-25, 113, 167, 232, 286, 328, 441-43, and 587-88, *Syritta pipiens*, **Allograpta obliqua*.

Conopidae.- *Conops brachyrhynchus*, Fig. 67, 117, 186, 221, 305, 356, 417-20, and 591-92, *Stylogaster biannulata*, Fig. 359, *Physocephala tibialis*.

Cyclorhapha- Calyptratae.

Cestridae.- *Gastrophilus equi*, Fig. 54, 138, 239, and 490-92.

Tachinidae.- *Archytas analis*, Fig. 68, 124, 197, 247, 309, 353, 468-69, and 604-05, *Siphona geniculata*, Fig. 355 and 458, *Gonia capitata*, *Ocyptera carolinae*, and *Gymnosoma fuliginosa*.

Dexiidae.- *Thelaira leucozona*, Fig. 65, 128, 196, 230, 301, 346, 473-74, and 595-96,

Sarcophagidae.- *Sarcophaga haemorrhoidalis*, Fig. 66, 130, 191, 244, 310, 350, 477-78, and 602-03.

Muscidae.- **Musca domestica*, Fig. 71, 72, 133, 194, 242, 304, 351, 465-67, 484-85 and 600-01, **Stomoxys calcitrans*, Fig. 354, 479, 480, and 599, *Myiospila meditabunda*, Fig. 120, *Pollenia rudis*, *Lucilia caesar*, and *Calliphora erythrocephala*.

Anthomyidae.- *Hydrotaea dentipes*, Fig. 69, 70, 127, 195, 241, 308, 349, 475-76, and 597-98, *Lispa nasoni*, Fig. 116 and 481, *Dexiopsis lacteipennis*, *Caenosia aurifrons*, and *Chorotophila* sp..

Cyclorhapha- Acalyptratae.

Scatophagidae.- *Scatophaga furcata*, Fig. 62, 135, 193, 246, 307, 357, 470-72, and 593-94.

Heteroneuridae.- *Heteroneura flavifacies*, Fig. 49, 126, 176, 229, 298, 340, 459-60, and 589-90.

Helomyzidae.- *Oecothoa fenestralis*, Fig. 48, 137, 192, 227, 290, 332, 452-53, and 580-81.

Borboridae.- *Borborus equinus*, Fig. 63, 136, 188, 231, 294, 342, 437-48, and 565-67, *Limosina ferruginata*, and *Sphaerocera persilla*.

Phycodromidae.- *Coelopa vanduzeei*, Fig. 58, 121, 182, 288, 337, 448-49, and 559-60.

Sciomyzidae.- *Tetanocera plumosa*, Fig. 55, 119, 180, 225, 302, 344, 463-64, 584 and 586, and *Sepidon fuscipennis*.

Sapromyzidae.- *Sapromyza vulgaris*, Fig. 60, 115, 171, 248, 289, 329, 409-10, and 553-54, *Sapromyza bispinosa*, *Minetta lupulina*, *Lonchaea polita*.

Ortalididae.- *Chrysomya demandata*, Fig. 64, 134, 181, 245, 295, 341, 456-57, and 557-58, *Tritoxa incurva*, *Chaetopsis aenea*, *Camptoneura picta*, *Pyrogota* sp?, and *Eumetopa* sp?.

Trypetidae.- *Euaresta aequalis*, Fig. 61, 131, 175, 240, 292, 347, 413-14, and 572-73, *Trypeta alba*, and *Straussia longipennis*.

Micropezidae.- *Calobata univitta*, Fig. 44, 114, 183, 236, 296, 348, 446-47, and 551-52.

Sepsidae.- *Sepsis violacea*, Fig. 46, 118, 184, 234, 287, 334, 439-40, and 582-83, and *Prochyli²a xanthostoma*.

Psilidae.- *Loxocera pectoralis*, Fig. 59, 123, 169, 235, 303, 339, 461-62 and 570-71.

Diopsidae.- *Sphyracephala bicornis*, Fig. 52, 94, 190, 293, 338, 450-51, and 585.

Ephydriidae.- *Ochthera mantis*, Fig. 56, 101, 187, 237, 297, 336, 444-45, 483, and 574-77, *Paralimna appendiculata*, and *Parydra bituberculata*.

Oscinidae.- *Chloropisca glabra*, Fig. 51, 132, 189, 306, 345, 430, 431, and 555-56, *Siphonella abdominalis*, and *Hippelates flavipes*.

Drosophilidae.- *Drosophila am^pelophila*, Fig. 45, 125, 172, 238, 291, 343, 454-55, and 563-64.

Geomyzidae.- *Chyromya concolor*, Fig. 50, 122, 179, 233, 299, 333, 411-12, and 568-69.

Agromyzidae.- *Desmometopa latipes*, Fig. 47, 129, 185, 228, 303, 330, 404-05, and 578-79.

Suborder- Eproboscidae.

Hippoboscidae.- *Olfersia ardeae*, Fig. 57, 139, 198, 249, 358, 488 and 606, *Melophagus ovinus*.

V. FIXED PARTS OF THE HEAD.

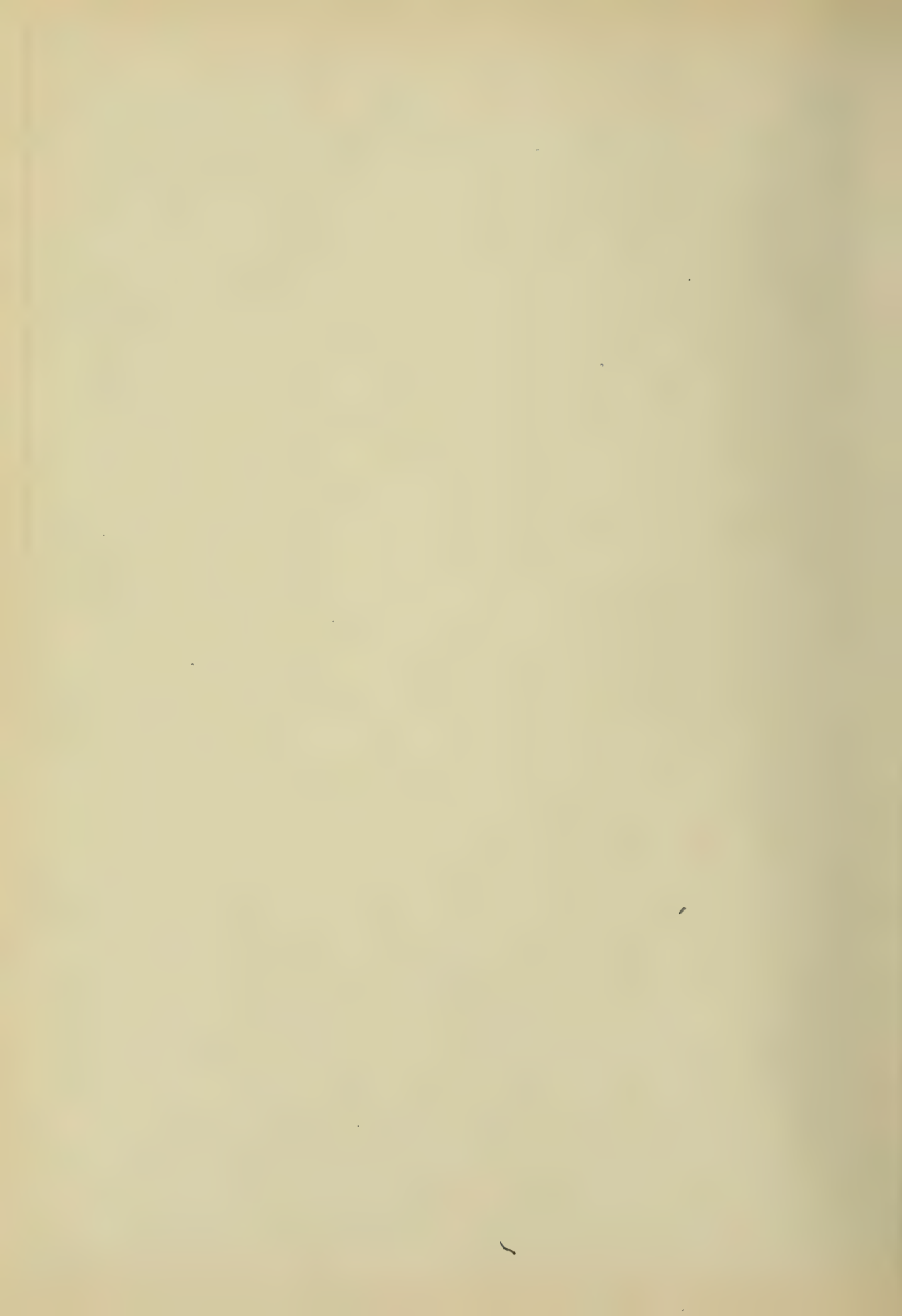
An hypothetical head-capsule of Diptera (Fig. 1) has a dorso-ventral extension. The epicranial suture is present on the meson and extends from the occipital foramen to a point ventrad of the antennae on the cephalic aspect. At this point it bifurcates and the two arms continue to the invaginations of the anterior arms of the tentorium which are located at the dorso-lateral angles of the clypeus. The three unpaired sclerites included within or ventrad of the fork of the epicranial suture are the front, clypeus and labrum. The fronto-clypeal suture is represented by a dotted line in the figure. The vertex includes all of the dorsal and cephalic aspects of the epicranium except ~~for~~ the front, while the genae are the regions of the vertex ventrad and mesad of the compound eyes. Two large compound eyes cover the lateral portions of the cephalic aspect. Three ocelli are located on the vertex. The occiput and postgenae constitute the caudal aspect of the head-capsule.

The tentorium of the hypothetical head-capsule has three pairs of invaginations homologous with the invaginations in generalized insects. The invaginations of the posterior arms are located ventrad of the occipital foramen at the distal ends of chitinated thickenings. The invaginations of the dorsal arms of the tentorium are on the cephalic aspect near the antennae and adjacent to the epicranial suture while the invaginations of the anterior arms of the tentorium are located in the epicranial suture and adjacent to the dorso-lateral angles of the clypeus.

The heads of all Diptera have a dorso-ventral extension and in this respect resemble the heads of many generalized insects. Some

of the primary sutures, sclerites and invaginations of the head of such an insect are present in a number of the ~~Hemiptera~~ ~~Meleagrina~~ and in a few of the Brachycera. The hypothetical head-capsule has been constructed from these forms. The heads of the Acalyptratae and Calyptratae are highly specialized by the modification, union, reduction, and the membranous development of parts; consequently very few if any primary characters remain which can be homologized with these structures. The membranous development of areas has been the most important process of specialization. The stippled areas on the figures show the extent of the membrane. The various parts of the head-capsule are discussed individually and in the order in which they were described for the hypothetical type. The heads of Diptera naturally fall into two groups by the presence or absence of a frontal suture and a ptilinum. The forms which do not possess a frontal suture are the more generalized.

Epicranial Suture.— The epicranial suture of all insects originates in the embryo. The stem of the suture on the dorso-meson represents the line along which the paired parts of the head meet while the arms of the suture represent the place of contact between the paired sclerites of the head and the mesal unpaired sclerites. The epicranial suture of an hypothetical dipterous head corresponds to the above description of the epicranial suture in the embryo. This suture in the hypothetical head ^{and} is also homologous with the epicranial suture found in the heads of generalized immature and adult insects of the more common orders. The following examples illustrate the homology between the hypothetical type and other insects. The epicranial suture in the larva of *Corydalis*, and in the generalized larvae of the Coleoptera, Lepidoptera and certain Hymenoptera is complete and the two arms of the epicranial



suture join with the lateral margins of the clypeus as has been^{14.}
shown in the hypothetical type.

The epicranial suture of the adults of the Orthoptera, Hemiptera and Hymenoptera also resemble this suture in the hypothetical head providing the following interpretation of this suture is accepted. In the adults of Gryllus and Periplaneta it is complete and similar to that of Corydalis except for a small portion of the arms which are wanting about the antennae and the lateral ocelli. The ventral ends of the arms are commonly called the fronto-genal sutures and they join with the clypeus as in Corydalis. All insects that possess a sucking type of mouth, such as the Hemiptera and Hymenoptera, usually show no signs of the stem of the epicranial suture. The arms, however, are distinct and form the lateral and dorsal boundaries of the large mesal piece commonly called the clypeus. A large number of the Diptera possess an epicranial suture which closely resembles that of the Hemiptera and Hymenoptera. On the basis of the above interpretation of the epicranial suture it has been possible to homologize the sutures, sclerites and the invaginations of the tentorium on the cephalic aspect. No other interpretation gave satisfactory results.

The epicranial suture in Mycetophila (Fig. 607) is complete and closely resembles the hypothetical type. Leia closely resembles Mycetophila except for the stem of the suture which is wanting dorsad ~~of the~~ of the median ocellus. The stem of the epicranial suture in Psorophora (Fig. 10 and 11) and Chironomus (Fig. 12) is represented by a distinct suture located in a deep fold on the meson. Other forms such as Rhabdophaga (Fig. 6), Mycetobia (Fig. 7), and Tabanus (Fig. 20) show depressions or thickenings along the

meson. These marks may have no significance. Outside of the above mentioned forms the stem of the epicranial suture is wanting.

The arms of the epicranial suture are present in many forms. This is the case with all but a few of the ~~Nemotocera~~ ^{Nemotocera}, with the majority of the Brachycera and with the families of the Cyclorhapha. They resemble, therefore, the adults of the Hemiptera and Hymenoptera. The arms are present as definite sutures between two chitinized areas in *Tabanus* (Fig. 20 and 21), *Leptis* (Fig. 35.), and the female of *Simulium* (Fig. 2). The epicranial suture is apparently wanting in the male of *Simulium* (Fig. 3) unless the lateral margins of the convex area represent it. In many genera the epicranial suture is represented by the edge of a chitinized sclerite. This is the case in *Chironomus* (Fig. 12), *Trichocera* (Fig. 16), *Psorophora* (Fig. 11), *Mycetobia* (Fig. 7), and *Dixa* (Fig. 19). The vertex in the genera named is membranous between the antennal fossae and the epicranial suture. *Sciara* (Fig. 17), *Rhabdophaga* (Fig. 6), *Bibiocephala* (Fig. 4 and 5) and possibly *Sciara* (Fig. 17) and *Bibio* (Fig. 14) have the arms of the epicranial suture represented by the chitinized margin of the vertex which is adjacent to the membranous portion of the fronto-clypeus. The location of the invaginations of the arms of the tentorium usually helps to determine the location of the epicranial suture. In *Ptychoptera* (Fig. 15) the invaginations of the anterior arms of the tentorium are located in the distinct v-shaped depression on the chitinized area ventrad of the antennae. Undoubtedly this depression marks the location of the epicranial suture. *Tipula* (Fig. 18) has a very specialized head and shows no epicranial suture or tentorium.

Only the arms of the epicranial suture are present among the

Brachycera. On the whole they are not as well developed in this group as they are in the Nemotocera. When these sutures are present, they are long and slit-like in all the genera except Tabanus. This condition is due to the fusion of the invaginations of the dorsal arms and the anterior arms of the tentorium along each suture. The arms of this suture in Tabanus (Fig. 20 and 21) unite the invaginations on each lateral half of the head and are not slit-like.

The arms of the epicranial suture in Tabanus (Fig. 20) have the usual inverted u-shape and their ventral ends terminate at the ventral margin of the head. The arms ventrad of the invaginations of the anterior arms of the tentorium are indistinct. The invaginations in Promachus (Fig. 22) are long and slit-like and located near the ventro-mesal angles of the compound eyes. The epicranial suture dorsad and ventrad of the invaginations are wanting. Promachus was undoubtedly derived from the same type as that from which Leptis and Tabanus were developed. From Leptis (Fig. 35) it is possible to homologize the arms of the epicranial suture of all the Brachycera and the Cyclorhapha. The arms of the suture extend dorsad from the ventral margin of the head in Leptis to a point ventrad of the antennae, where they unite and enclose a convex mesal area called the fronto-clypeus. This suture in Platypeza (Fig. 32) closely resembles ^{that of} Leptis. The ~~the~~ dorsal ends ^{of the arms} are wanting in Psilocephala (Fig. 36), Mydas (fig. 30), Exoprosopa (Fig. 29), Eristalis (Fig. 23 and 25), Scenopinus (Fig. 41 and 42) and in other forms. Scenopinus shows a striking variation in that the vertex between the antennae and the fronto-clypeus is membranous and no epicranial suture can be traced thru this membrane.

Stratiomyia (Fig. 27) shows a unique development of the slits in that they extend mesad rather than dorsad. This condition is undoubtedly a secondary development. The epicranial suture of Lonchoptera, Aphiochaeta, Pipunculus, and Empis is discussed under fronto-clypeus.

No epicranial suture or slit-like invaginations are apparently present in any Dipteron that possesses a frontal suture or a ptilinum. Since the tentorium on the cephalic aspect and the arms of the epicranial suture are usually closely associated in insects, there is every reason to believe that these thickenings mark the course of the the suture. Furthermore the location of the thickenings of the tentorium is very similar to the location of the slit-like invaginations of Leptis (Fig. 35). These thickenings have been considered as marking the course of the epicranial suture. The extent of the tentorial thickenings varies considerably as seen in the figures. In Tetanocera (Fig. 55), Chloropisca (Fig. 51), Heteroneura (Fig. 49) and others, the tentorial thickenings extend to the antennale fossae. No sutures are present between the dorsal ends of these thickenings.

Fronto-clypeus.- The front and clypeus of all insects are unpaired sclerites located between the arms of the epicranial suture. The labrum is also an unpaired sclerite attached typically to the ventral ~~ventral~~ margin of the clypeus. These three sclerites and their parts are not always distinguishable. This is particularly true of the front and clypeus in Diptera. The dotted, transverse line uniting the invaginations of the anterior arms of the tentorium in the hypothetical head indicates the location of the fronto-clypeal suture. In a few of the Orthorhapha, suture-like marks, depressions or thickenings extend across the chitinized

portion of the fronto-clypeus. These marks in *Chironomus* (Fig. 18), *Mycetophila* (Fig. 607) and *Rhabdophaga* (Fig. 6) resemble the fronto-clypeal suture as indicated on the hypothetical type. It is possible that they are remnants of this suture. With the exception of the forms named, one cannot be sure of the presence of a fronto-clypeal suture; consequently the entire area between the labrum and the arms of the epicranial suture has been designated as the fronto-clypeus. The absence of the fronto-clypeal suture in *Diptera* is not unusual since it is wanting in many generalized insects. For those who may wish to divide the fronto-clypeus into two areas, the dorsal half would be the front and the ventral half the clypeus. A large portion of the fronto-clypeus is membranous in *Rhabdophaga* (Fig. 6), *Rhyphus* (Fig. 9), and *Sciara* (Fig. 17) and the chitinized part greatly reduced. The variations found in the *Nemotocera* may be seen on the figures.

The *Brachycera* show two lines of development in the modification of the area enclosed by the arms of the epicranial suture. Both of these started from a form which possessed an epicranial suture similar to that of *Leptis* (Fig. 35). The line of development, as seen in *Psilocephala*, *Platypeza*, *Scenopinus*, *Lonchoptera* and *Aphiochaeta*, is considered first. The chitinized fronto-clypeus of *Leptis* resembles the fronto-clypeus of a number of the *Nemotocera*, as *Sciara* (Fig. 17). From this simple condition it is possible to develop the type of fronto-clypeus found in *Psilocephala* (Fig. 33 and 36). This came about by a membranous development on the meson and on the lateral margins, and the loss of the arms of the epicranial suture directly ventrad of the antennae. The membranous development of the fronto-clypeus of *Platypeza* (Fig. 32) resembles *Psilocephala* and *Scenopinus* (Fig. 41 and 42)

and belongs to this same line. In this genus the antennae are adjacent^{18.} to the fronto-clypeus and no portion of the chitinized vertex exists between them. The form of the chitinized portion of the fronto-clypeus resembles closely that of *Platypeza*. *Aphiochaeta* (Fig. 31) and *Lonchoptera* (Fig. 37) apparently belong to this same series. If such is the case, the arms of the epicranial suture do not project dorsad but they are represented by the nearly straight ventral margin of the cephalic aspect. This condition must have come about by the straightening out of the usual u-shaped depression and the chitinized part of the fronto-clypeus is located ventrad of the margin of the head. A similar type of development occurs in *Biblio* (Fig. 14). The tentorial thickenings along the ventral margin of the head in *Lonchoptera* is favorable evidence for the above interpretation. All other figures of the Brachycera and the *Cyclorhapha* show the presence of a sclerite designated as the tormae and located ventrad of the fronto-clypeus and this condition places them in the line of specialization which leads toward a muscid type.

The fronto-clypeus is present in all Diptera and constitutes a prominent portion of the head-capsule. In *Tabanus* (Fig. 20 and 21) the fronto-clypeus is ~~all~~^{entire} the area ventrad of the epicranial suture outside of the tormae and the labrum. The sutures separating the fronto-clypeus from the genae ~~is~~^{are} very indistinct. No arms of the epicranial suture are present in *Promachus* (Fig. 22), *Empis* (Fig. 26), and *Lipunculus* (Fig. 38); consequently the dorsal extent of the fronto-clypeus can not be determined and the area ventrad of the antennae is considered as the fronto-clypeus. The fronto-clypeus of *Mydas* (Fig. 30) resembles that of *Leptis* and

from a type similar to *Mydas*, it is possible to develop the fronto-clypeus of *Exoprosopa* (Fig. 29), *Eristalis* (Fig. 25), and probably *Stratiomyia* (Fig. 27). The fronto-clypeus of *Mydas* closely resembles that of the *Acalyptratae* and the *Calyptratae* as will be seen by comparing *Mydas* with *Tetanocera* (Fig. 55), *Chloropisca* (Fig. 51), and *Chrysomya* (Fig. 50). It is not a completely chitinized area in all of the genera studied and the significance of this mesal membranous area in *Sepsis*, *Oeciothea* and *Calobata* has been suggested in the discussion on the ptilinum.

Torma.- The tormae in generalized insects are chitinized pieces which belong to the lateral portions of the epipharynx in the region of the clypeo-labral suture and connect with the clypeus or labrum at the lateral ends of the suture.

The tormae of generalized *Diptera* also connect with the inner surface of the ventral portion of the fronto-clypeus. They are not well developed structures or readily distinguishable from the fronto-clypeus in a number of the *Nemotocera*. The reason for this seems to be due to the decidedly convex nature of the fronto-clypeus and the close proximity of its lateral portions with the lateral margins of the epipharynx. The tormae of *Leptis*, *Psilocophala*, *Scenopinus*, *Aphiochaeta* and *Lonchoptera* connect with the fronto-clypeus and thus resemble the *Nemotocera* and the hypothetical type. In *Tabanus* the tormae (Fig. 494) resemble the above genera in their connection with the fronto-clypeus but they have been enlarged ventrad until they are exposed between the clypeus and the labrum. The exposed portions of the tormae resemble two small, triangular sclerites with their pointed ends meeting on the meson. This condition is not unusual since they resemble closely the exposed portions of the tormae located

at the lateral ends of the clypeo-labral suture in *Cryllus*. *Simulium* also shows exposed portions of the tormae at the ventro-lateral angles of the fronto-clypeus.

The inverted chitinized v-shaped piece ventrad of the fronto-clypeus in *Mydas* (Fig. 30) has undoubtedly been derived from the fusion of the tormae of some form resembling *Tabanus* (Fig. 20). All connection between the tormae and the fronto-clypeus is lost in *Mydas*. From the type of tormae found in *Mydas* it is possible to develop the tormae of all other genera. The tormae vary in shape and location as seen in the cephalic views of the head. In *Exoprosopa* (Fig. 29), *Eristalis* (Fig. 33) and *Stratiomyia* (Fig. 27) they show a striking development in that they are located within deep emarginations of the ventral margin of the fronto-clypeus. The tormae of *Empis* (Fig. 26) closely resembles that of *Mydas*, therefore it belongs to this line of development. In *Pipuncululus* (Fig. 38) the tormae resemble the fronto-clypeus of *Sciara* (Fig. 17) but as a matter of fact the fronto-clypeus is the area ventrad of the antennae as shown by the location of the dorsal arms of the tentorium. The tormae of the Acalyptratae are usually a crescent-shape while among the Calyptratae they resemble the type found in *Mydas*.

Ptilinum.— A deep, inverted u-shaped groove is present in the heads of all the Acalyptratae and the Calyptratae dorsad of the antennae. This groove is called the frontal suture and marks the line of invagination of the large membranous pouch, the ptilinum. In *Sphyracephala* (Fig. 52) the frontal suture is v-shaped, due to the peculiar development of the head. The extent of the invagination of the ptilinum is indicated by a dot-and dash line in the

drawings of the cephalic and lateral views of the head-capsule.

The origin of the ptilinum has been a mystery to morphologists. After a careful examination of the heads of the Brachycera and the Cyclorrhapha no definite data were found which would throw any light on its origin. A few forms, however, suggested a possible way in which it might have been developed. The frontal suture and ptilinum are comparatively small in *Tetanocera* (Fig. 55), *Sapromyza* (Fig. 60), *Conops* (Fig. 17), *Ochthera* (Fig. 56), and *Chloropisca* (Fig. 51). These genera gave no clue to the early stages of its development unless the thinly chitinized condition of the fronto-clypeus of *Chloropisca* has some significance. It seems evident that the frontal suture was once a membranous area which became invaginated to form a membranous pouch or ptilinum. If this is the case, the mesal membranous area of the fronto-clypeus of *Sepsis* (Fig. 46), *Oeciothea* (Fig. 48), *Calobata* (Fig. 44), and *Desmometopa* (Fig. 47) would be very significant. The ptilinum might possibly have originated from some form similar to *Scenopinus* (Fig. 41) where the ventral margin of the chitinized vertex is located dorsad and laterad of the antennae. It seems quite possible that the membrane along this margin became invaginated in the early stages of the development of the ptilinum. The above suggestions may or may not be correct. The real solution to the problem undoubtedly rests upon a careful study of its pupal development.

Labrum.— The labrum of an hypothetical dipterous head (Fig. 140 and 493) is a distinct, chitinized, tongue-like structure connected with the ventral margin of the clypeus. The shape and size of the labrum is identical with the shape and size of the

23.

epipharynx which is located on its caudal aspect. The labrum and epipharynx are joined together by a membrane along their lateral margins. These two structures thus act as one organ and they have rightly been called the labrum-epipharynx. The above relation of the labrum to the epipharynx and the fronto-clypeus resembles closely the corresponding conditions in the Orthoptera.

In a general way the labrum of all the genera studied resembles the hypothetical type described above. It varies, however, in shape and degree of chitination. In *Iromachus* (Fig. 22), *Psorophora* (Fig. 10 and 11), and the female of *Tabanus* (Fig. 20) it is completely chitinated and separated from the fronto-clypeus by a suture. In all other genera there is a distinct membranous area present between the fronto-clypeus and the labrum. This area is very extensive in the *Cyclorrhapha* and includes the tormae. The labrum of a few scattered genera such as *Rhabdophaga* (Fig. 6), *Mycetobia* (Fig. 7), *Chironomus* (Fig. 12), *Scenopinus* (Fig. 41) and others is completely membranous while in others it is nearly so as in *Mydas* (Fig. 30). The figures of the cephalic aspect of the head and the lateral views of the epipharynx and the hypopharynx show the shape and extent of the chitination of the labrum.

The labrum of *Dixa* (Fig. 501), *Trichocera* (Fig. 499), *Sciara* (Fig. 513), *Biblio* (Fig. 523), *Simulium* (Fig. 497), *Culicoides* (Fig. 521), *Tabanus* (Fig. 20) and *Dolichopus* (Fig. 528) is distinctly separated from the epipharynx by a membrane. This condition is best seen from a lateral view. The majority of the forms studied have little or no membrane between the labrum and the epipharynx. This is particularly true of the *Cyclorrhapha*.

The surface of the labrum of all the Diptera is more or less convex. In a large number of the genera the convexity is very decided and of such a nature as to surround the cephalic and lateral aspects of the epipharynx. The epipharynx in these forms can only be seen from a caudal view. Among the Calyptratae, the labrum and epipharynx are firmly united into one piece.

The labrum of *Simulium* (Fig. 2 and 489) is unique in that the chitinized part consists of a narrow mesal piece which bifurcates at its distal end. These bifurcations give rise to special small hook-like structures which have been incorrectly interpreted as mandibles, Smith- 1890. The labrum and epipharynx of *Psorophora* (Fig. 504) fit together very closely. By careful dissection they may be separated as seen in the drawing. So far as observed no membrane is present between them. The proximal end of the labrum is unique in its crook-like form, with which muscles connect.

Vertex.- The vertex of an hypothetical head is the paired continuous areas on the cephalic aspect of the epicranium. It is interpreted as including all the cephalic and dorsal aspects of the epicranium except the front. In a number of the Diptera, as heretofore described, the stem of the epicranial suture is present and marks the line of fusion of the two halves of the vertex upon which the ocelli and the antennae are located. The shape and size of the chitinized portion of the vertex is largely determined by the size of the compound eyes, the location and extent of the membranous area about the base of the antennae, and the location of the arms of the epicranial suture. The variations in the size and shape of the vertex are shown in the figures of

the cephalic aspect of the head.

The region of the vertex ventrad and mesad of each compound eye is a gena. The size and extent of the genae ^{are} ~~are~~ dependent upon the location of the compound eyes and the ventral extension of the head-capsule. The figures show considerable variation in these respects.

Compound Eyes and Ocelli.- The compound eyes of a hypothetical head are large oval structures located on the cephalo-lateral aspects of the head-capsule. They cover from one-half to two-thirds the entire cephalic aspect and their caudal margins are adjacent to the lateral margins of the head. The compound eyes of the majority of the Diptera resemble in general the hypothetical type. The shape and size of the compound eyes varies considerably with the different species. Variations ~~among~~ are more prevalent in the families of the Orthorhapha. This variability agrees with the decided variability of other parts. In such genera as *Tipula* (Fig. 95), *Psorophora* (Fig. 96) and *Limnobia* (Fig. 93) the compound eyes are exceptional in that they extend onto the caudal aspect of the head. The variations in shape are well illustrated by the numerous figures.

The compound eyes show secondary sexual characters in a greater number of species than any other fixed or movable part. This sexual variation is most prevalent among the *Nerotocera* and the *Brachycera*, but was not observed in the *Acalyptratae*. Among the *Calypttratae*, slight differences occur in *Musca* (Fig. 71 and 72) and *Hydrotaea* (Fig. 69 and 70). When sexual variation occurs, the eyes of the male are larger than those of the female and they are usually adjacent along a portion of their mesal margins.

Such eyes are said to be holoptic while in all the females and in some males where the eyes are distinctly separated, they are dichoptic. The extent of the holoptic condition depends upon the size of the eyes and the location of the antennal fossae, as in *Simulium* (Fig. 2 and 3) and *Biblio* (Fig. 13 and 14). In the male of *Biblio* the compound eyes are adjacent along their mesal margin and the antennal fossae are located ventrad of the eyes. The extent and nature of the sexual variation is shown in the figures. The heads of the male and female have been drawn when decided differences are present.

The facets or ommatidia of the compound eyes vary in number, form, and size thruout the order. Among the *Nemotocera* they are usually large and not as closely compacted as in the *Cyclorhapha*. An interesting variation occurs in the male of *Simulium* where the facets of the ventral half of the eye are smaller than those of the dorsal half. This difference in size of the facets is also true of the female of *Bibliocephala* (Fig. 5). In the male of *Biblio* (Fig. 154), the facets in the ventro-caudal portions of the eyes are smaller than those in the remainder. The compound eyes of *Bibliocephala* and *Blepharocera* are divided ~~are~~ are into a dorsal and ventral portion by a transverse constriction where the ommatidia are wanting. This constriction is also present in *Biblio* but in this form it is confined to the caudo-ventral portion of the eye.

The drawings of the lateral views of some heads show a dash or solid line around the margins of the compound eyes. This line indicates the extent of the infolding of the head-capsule adjacent to the compound eyes. This infolding or ocular sclerite

is figured only for those species where it is closely related 27.
to the external markings found on the caudal aspect. The influence of this invaginated edge will be more fully discussed later.

The three ocelli of the hypothetical head-capsule (Fig. 1) are arranged in the form of a triangle and located on the cephalo-dorsal aspect of the vertex. The median ocellus occurs in the epicranial suture and somewhat ventrad of the lateral ocelli. In *Leia* the median ocellus is located in the epicranial/somewhat dorsad of the bifurcation and the other two ocelli are located somewhat laterad of it. This location of the ocelli in the *Diptera* agrees with Comstock's idea concerning the caudal migration of the ocelli in specialized insects. In generalized insects all three ocelli may be located on the front or the lateral ocelli may be in the arms of the epicranial suture or on the vertex while the median ocellus is on the front. The ocelli in the *Hymenoptera* and *Hemiptera* are similar in location to those of the *Diptera*.

Leia is the only form studied which possesses ocelli and a well marked stem of the epicranial suture. The chitinized, secondary, y-shaped thickenings on the ocellar triangle of *Rhyphus* (Fig. 9) and *Mycetobia* (Fig. 7) should not be confused with the epicranial suture. The ocelli are wanting in a large number of the *Nemotocera* and in *Tabanus*, *Conops* and *Olfersia*. Three ocelli are present in all other species of *Diptera* except *Oncodes* (Fig. 53) where there are only two. The figures show such variations as occur in the various ocellar groups.

Caudal Aspect-Occiput and Postgenae.- No sutures occur on the caudal aspect of an hypothetical head-capsule (Fig. 73) except

the epicranial suture. This absence of sutures makes it impossible to definitely locate the boundaries of the occiput and the postgenae. The following interpretation is based upon a study of the occiput and postgenae of generalized insects such as the Orthoptera. The occiput comprises all the area dorsad of an imaginary transverse line drawn thru the middle of the centrally located occipital foramen. The areas ventrad of this line and laterad of the mesal membranous areas are the postgenae. The occiput undergoes a secondary development about the margin of the occipital foramen. The structures pertaining to this modification have been designated as the parocciput. Each postgena is also secondarily differentiated along its mesal margin by a chitinated thickening which extends between the occipital foramen and the invaginations of the posterior arms of the tentorium. This thickening has been designated as the parapostgenal thickening while the area mesad of it is the parapostgena. The two mesal projections of the parocciput on the lateral margin of the occipital foramen serve as points for the articulation of neck sclerites, and mark the ventral boundary of the occiput.

The occipital foramen is centrally located in all but a few genera such as *Tipula* (Fig. 95), *Limnobia* (Fig. 93), *Psorophora* (Fig. 96), and *Bibio* (Fig. 92) where it is near the dorsal margin. The size of the occipital foramen is more or less constant thruout the order but in *Psychoda* (Fig. 82) and *Promachus* (Fig. 84) it is comparatively much larger than in *Pipunculus* (Fig. 106) and *Exoprosopa* (Fig. 98). The shape of the occipital foramen varies somewhat, but usually it is in the form of a figure eight. The constrictions in the lateral margins are generally due to

the mesal projections of the parocciput which vary to some extent in their location. The projections in *Exoprosopa* (Fig. 98) *Pipunculus* (Fig. 106) and *Mydas* (Fig. 99) meet on the meson and completely divide the occipital foramen into two openings. The neck sclerites always articulate with these mesal projections and are represented in a number of the figures.

The occiput of all the genera figured resembles in general the occiput of the hypothetical head since no sutures separate the vertex, the occiput, and the postgenae. The location of the occipital foramen and the contour of the caudal surface determines the amount of variation in the occiput as well as the postgenae. In some genera, *Empis* (Fig. 164) and *Bibiocephala* (Fig. 150), the caudal aspect is convex, while in others, *Exoprosopa* (Fig. 98) and *Pipunculus* (Fig. 106), it is decidedly concave. Suture-like markings or depressions are present near the dorsal margin of the caudal aspect in the heads of *Tabanus* (Fig. 74), *Stratiomyia* (Fig. 164), *Biblio* (Fig. 91 and 92), *Bibiosephala* (Fig. 81), *Leptis* (Fig. 103), *Psilocephala* (Fig. 100) and others. These depressions mark the place of contact of the mesal portions of the ocular sclerites with the head-capsule and are in no way homologous with the sutures about the occiput in generalized insects.

The area about the dorsal and lateral margin of the occipital foramen, the parocciput, is more or less differentiated from the remainder of the occiput in all the species studied. Among the more generalized forms, *Bibiocephala* (Fig. 83), *Trichocera* (Fig. 78), *Tipula* (Fig. 95), *Sciara* (Fig. 81), and *Eittacomorpha* (Fig. 85), it is only a thickened edge, but in a large number of species thruout the order it is a clearly defined piece and set off from

the occiput proper by a secondary suture. The indefiniteness of this piece in a large number of the generalized Diptera and the want of an homologous part in generalized insects supports the view that it is only a secondary modification of the occiput.

The parocciput, in most genera, occurs as a narrow piece about the dorsal and lateral margin of the occipital foramen and its ventral ends project mesad. In the heads of the *Cyclorhapha* three secondarily developed, chitinized thickenings arise from the ental surface of the parocciput; two of these project dorso-laterad from the lateral portions of the parocciput and the third is located on the meson. These thickenings are also present in some of the Brachycera such as *Dolichopus* and *Pigunculus*. Their greatest development is found in *Eristalis* where the two dorso-lateral thickenings extend to the caudal margins of the compound eyes and the third thickening on the meson bifurcates a short distance dorsad of the occipital foramen and the two arms connect with dorso-mesal angles of the compound eye. The dorso-lateral thickenings on the whole are better developed in the genera figured than the thickening on the meson. In *Thelidora* (Fig. 128) and *Musca* (Fig. 133), the dorso-lateral thickenings project dorsad to the margin of the head. The area included between them is called the epiccephalon or occiput by different writers and it is also entirely different in origin from a similar area found in *Tabanus* (Fig. 74) and others and given the same name. These names and others used by systematists have no morphological significance for they cannot be homologized with the primary sclerites of a generalized insect.

The postgenae of the hypothetical dipterous head has been care-

fully compared with the heads of generalized insects such as the Orthoptera. The mesal membranous area between the postgenae is homologous with the membrane of the neck and the membrane surrounding the proximal ends of the maxillae and the labium. There are no sutures or sclerites along the mesal portions of the postgenae in generalized insects such as the Orthoptera; consequently the parapostgenae described above cannot be homologous with any primary sclerite. The parapostgenae are undoubtedly special modifications of the postgenae.

The postgenae and the parapostgenae of the majority of the Nematocera resemble the hypothetical head. In Chironomus and Trichocera the parapostgenal thickenings are wanting. The invaginations of the posterior arms of the tentorium in Simulium (Fig. 77) are adjacent to the occipital foramen, consequently the parapostgenae are confined to the lateral margins of the occipital foramen. In Tabanus the invaginations are also located adjacent to the occipital foramen and the postgenae are connected by a broad area ventrad of the occipital foramen in the male and by a narrow strip in the female.

The area ventrad of the occipital foramen is a continuous chitinized piece in all of the Cyclorhapha and the Orthorhapha. There is only one probable explanation of the origin of this area. It has been derived from the fusion of the mesal margins of the postgenae. The evidence for this interpretation is found in a number of the Nematocera. The mesal margins of the postgenae in Trichocera (Fig. 78) and Sciara (Fig. 81) are curved mesad and in some cases actually join as in the female of Bibiocrphala (Fig. 83). The peculiar elongated heads of Lirrobia (Fig. 93), Tipula (Fig.

95), and *Psorophora* (Fig. 96) show a distinct depressed line on the meson along which the postgenae have joined. In a number of the genera of the *Orthorrhapha* and the *Cyclorrhapha* the ventral margin of the caudal aspect is decidedly concave. This condition may be due to a former stage in the development of the fused postgenae. In all cases where the area ventral of the occipital foramen is chitinized, the invaginations of the posterior arms of the tentorium are adjacent to the occipital foramen and the attachments of the maxillae are removed to or beyond the ventral margin of the head. *Sciara* (Fig. 81) is a good example of an early stage in the development of the above relationship. The variations in the shape and extent of the postgenae and parapostgenae are well illustrated by the figures.

Tentorium.— There is present within the head of generalized insects a definite arrangement of chitinized rods and plate-like structures which go to support the internal organs and furnish places for the attachment of muscles. These rods or plates arise from three pairs of openings on the head known as the invaginations of the anterior arms, dorsal arms, and posterior arms of the tentorium. The invaginations of the anterior arms are usually associated with the lateral margins of the clypeus, with one of the points of articulation of the mandibles, and frequently with the distal ends of the epicranial suture. The invaginations of the dorsal arms are associated with the points of attachment of the antennae and near the dorsal portions of the arms of the epicranial suture. The invaginations of the posterior arms are associated with the occipital foramen and the points of attachment

of the maxillae. The three pairs of arms unite within the head; the small dorsal arms unite with the large anterior arms and these in turn join with the posterior arms which are confined to the caudal portion of the head-capsule. The free ends of the posterior arms are fused and form the body of the tentorium.

The tentorium undergoes a considerable amount of variation in the different orders, but the above associations between the invaginations and the fixed and movable parts of the head are always retained by the more generalized members of each order so far as observed. This is also true for a generalized hypothetical dipterous head. The tentorium of such a head (Fig. 140 and 141) is considerably modified when compared with the tentorium of a generalized insect. Two pairs of invaginations are present on the cephalic aspect of the head (Fig. 1). The dorsal indistinct pair just ventrad of the antennae are homologous with the invaginations of the dorsal arms of the tentorium while the prominent pair of invaginations ventrad of these and located in the epicranial suture and adjacent to the lateral ends of the fronto-clypeal suture are the invaginations of the anterior arms of the tentorium. One pair of invaginations is present on the caudal aspect of the head-capsule (Fig. 73) somewhat ventrad of the ventro-lateral margins of the occipital foramen. These are the invaginations of the posterior arms of the tentorium. Each lateral half of the tentorium is Y-shaped, the stem of the Y arises from the invaginations on the caudal aspect and its caudal portion is a part of the posterior arms of the tentorium. The large ventral arm of the Y together with the cephalic portion of the stem is the anterior arm and the small dorsal arm is the dorsal arm of the tentorium.

These two arms connect with their respective invaginations on the cephalic aspect. The body of the tentorium is apparently represented by small, rudimentary, mesal projections arising from the posterior arms near the caudal portion of the stem of the Y.

The association between the movable appendages and the invaginations of the tentorium is discussed under the respective appendages. From this point ~~on~~ the tentorial structures as they occur in the various genera are compared with the hypothetical type and the line of specialization noted. The forms without a ptilinum are considered first. The parts of the free tentorium, not completely fused with the head-capsule are indicated^a in the figures by dotted lines.

The tentorium of *Tabanus* (Fig. 142 and 143) is generalized and closely resembles the hypothetical type; consequently it furnishes a good starting point for a discussion. Two invaginations are present on the cephalic aspect (Fig. 20); of these the invaginations for the anterior arms are the more prominent. The dorsal arms arise from the head-capsule just ventro-laterad of the antennae and connect with the arms of the epicranial suture. The invaginations for the anterior arms are located near the distal ends of the epicranial suture. The invaginations on each lateral half of the head are joined together by the epicranial suture and resemble the hypothetical type. Two pairs of invaginations are also present on the cephalic aspect of *Simulium* (Fig. 2 and 3) but in this genus they are not as prominent as in *Tabanus*. They are located on the vertex adjacent to the compound eyes. In the female the arms of the epicranial suture are well defined and the invaginations are closely adjacent to them while in the male the sutures are wanting. *Tabanus* and *Simulium* are the only forms

figured which show two distinct pairs of invaginations on the cephalic aspect. All other genera have only one pair and these are of two types. They are either long and slit-like or they resemble small pits or darkened spots on the ectal surface. The long, slit-like invaginations found in *Leptis* (Fig. 35), *Psilocephala* (Fig. 36), *Platypeza* (Fig. 32), *Scenopinus* (Fig. 41), *Exoprosopa* (Fig. 29), *Fromachus* (Fig. 22), *Stratiomyia* (Fig. 27), *Mydas* (Fig. 30), and *Eristalis* (Fig. 25) have a special significance which will be more fully discussed later. The small, pit-like invaginations are present among the *Nemotocera* and in *Pipunculus* (Fig. 38) and *Empis* (Fig. 26). These are located on the chitinized area of the vertex or the fronto-clypeus adjacent to the arms of the epicranial suture and usually close to the compound eyes. Their location and structure indicates that they are the invaginations of the anterior arms of the tentorium. In a few genera of the *Orthorhapha*, such as *Lonchoptera* (Fig. 37), *Tipula* (Fig. 18), and *Aphiochaeta* (Fig. 31) no invaginations are present on the cephalic aspect of the head.

One pair of invaginations for the posterior arms of the tentorium is present on the caudal aspect of the heads of all genera examined except *Oncodes* (Fig. 105), *Olfersia* (Fig. 139), *Tipula*, and a few other species where it is difficult to be sure of their presence. The invaginations in *Bibliocephala* (Fig. 83), *Trichocera* (Fig. 78), *Dixa* (Fig. 79), *Rhyphus* (Fig. 80), *Sciara* (Fig. 81), *Psychoda* (Fig. 82), *Rhabdophaga* (Fig. 86), *Chironomus* (Fig. 86), *Bittacomorpha* (Fig. 85), *Mycetophila* (Fig. 607), and *Mycetobia* (Fig. 90) are decidedly ventrad of the occipital foramen and adjacent to the proximal ends of the maxillae. They are connected

with the lateral margins of the occipital foramen by means of the parapostgenal thickenings except in *Chironomus* and *Trichocera*. The above forms closely resemble the hypothetical type. In a few genera of the *Nemotocera*, such as *Psorophora* (Fig. 96) and *Simulium* (Fig. 77), the invaginations are adjacent to the occipital foramen. This is characteristic of these invaginations in the *Brachycera* and the figures show the details of the variations in the position of the invaginations of the posterior arms of the tentorium.

Two lines of specialization occur in the tentorium of the *Diptera*. One is the reduction of the dorsal arms while the other is the union of the dorsal arms and the anterior arms. The two types of invaginations described for the cephalic aspect of the head bear directly upon this problem. The most important evidence in proof of these two types of development is found in the structure of the arms.

In *Sciara* (Fig. 150), *Bibio* (Fig. 153 and 154), *Psorophora* (Fig. 159), *Trichocera* (Fig. 158), *Bibiocephala* (Fig. 155), *Dixa* (Fig. 163) and others, two long narrow rods extend on each side between the invaginations on the caudal aspect and the invaginations on the cephalic aspect. These rods are composed of the posterior arms and the anterior arms of the tentorium. The dorsal arms are completely reduced in these forms. Other genera show completely developed dorsal arms or rudiments of the same. The dorsal arms are distinct and free in *Pipunculus* (Fig. 151). They arise from the anterior arms and project cephalad to the cephalic aspect of the head, where they connect with small but distinct ental projections adjacent to the antennae. The cephalic ends of the

the dorsal arms are very delicate and easily broken in dissections. There are no invaginations on the ectal surface. In *Chironomus* (Fig. 152) the tentorial arms are swollen near the middle of their length and the distinct humps on the dorsal side are interpreted as rudiments of the dorsal arms. *Fromachus* (Fig. 147) has two long, free, finger-like projections arising from the ocular sclerite near the antennae which project toward the tentorium proper. These projections are undoubtedly dorsal arms of the tentorium that have retained their connection with the ocular sclerite near the mesal margin of the compound eye but have lost their connection with the tentorium proper. A similar relationship between the dorsal arms and the ocular sclerite is present in *Tabanus*.

The above described tentorium of the *Nemotocera* are located in the ventral half of the head-cavity and their situation is dependent upon the position of the invaginations. Usually the invaginations of the anterior arms are located ventrad of the invaginations of the posterior arms, but *Bibiocephala* (Fig. 155) is an exception to this rule if the tentorium in this genus is composed of only the anterior and posterior arms. There is no evidence to show that this is not the case. In some genera such as *Lonchoptera* (Fig. 177), *Rhabdophaga* (Fig. 170) and *Empis* (Fig. 164), they are not free rods extending thru the head cavity, but are completely united with the ventral margin of the head or nearly so. The tentorium of *Aphiochaeta* (Fig. 174) is reduced to two small ental projections adjacent to the occipital foramen while in *Tipula* (Fig. 178) the tentorium is apparently wanting.

Among the majority of the *Brachycera* the tentorial arms are

specialized by fusion and *Tabanus* (Fig. 143) illustrates an early stage in this development. The principal difference between the tentorium of *Tabanus* and the hypothetical type is the presence of a thin chitinized plate in the V-shaped opening between the anterior and dorsal arms. *Simulium* (Fig. 144) has a similar plate and these two genera clearly demonstrate the first stage in the fusion of these two arms. The cephalic end of the tentorium in *Promachus* (Fig. 147), *Mydas* (Fig. 146), *Leptis* (Fig. 145), *Scenopinus* (Fig. 149), and *Exoprosopa* (Fig. 162) is a broad uniformly chitinized triangular area. This condition is accounted for on the basis of the union of the anterior and dorsal arms and the invaginations on the cephalic aspect of these forms agree in all respects with this interpretation. In *Tabanus* (Fig. 20) the invaginations on each side are joined together by the epicranial suture while in the above forms the invaginations are slit-like and occupy the greater part of the arms of the epicranial suture. The slit-like invaginations are easily explained if the anterior and dorsal arms are considered as fused.

The posterior arms of the tentorium of the *Newtocer*a and the *Brachycera* vary in shape, size and location. The anterior and posterior arms are united within the head and no sharp line can be drawn between them. The body of the tentorium is represented by small mesal projections on the mesal surface of the posterior arms of most genera.

Many interesting features occur in the modifications of the tentorium of this group. In *Dolichopus* (Fig. 43 and 168) it appears to be fused with the dorsal margin of the slit-like openings on each side between the mesal margin of the compound eye

and the fronto-clypeus. The tentorium of *Mydas* (Fig. 146) is large and tubular and it is possible to push a good sized needle thru the opening of the anterior arms to the opening of the posterior arms.

The tentorium of the genera possessing a ptilinum differ principally from the foregoing in the degree of fusion with the head capsule. In most genera of this group the tentorium is completely united with the head, but in a number of the Acalyptratae the tentorial arms arise as free rods from the invaginations on the caudal aspect and project to the latero-ventral margins of the head-capsule with which they unite and continue cephalad as thickenings adjacent to the ventral margin of the head as in *Sapromyza* (Fig. 171), *Loxocera* (Fig. 169), *Euaestha* (Fig. 175), *Calobata* (Fig. 183), *Chrysomya* (Fig. 181), *Drosophila* (Fig. 172), *Chyro-myia* (Fig. 179), *Heteroneura* (Fig. 177), and *Tetanocera* (Fig. 180). Among those forms, where the tentorium is completely fused with the head as in *Sepsis* (Fig. 184), *Chloropisca* (Fig. 189), *Coelopa* (Fig. 182), and *Borborus* (Fig. 188), it is a continuous thickening from the latero-ventral angle of the occipital foramen to the cephalo-ventral aspect of the head-capsule. The tentorium between the invaginations for the posterior arms and the ventro-lateral margins of the head-capsule is apparently wanting in *Musca* (Fig. 194), *Thelaira* (Fig. 196), *Archytas* (Fig. 197) and others; in one or two cases it is possible to trace a faint mark which would indicate the line of connection. The tentorium among some of the genera of the Acalyptratae and the Calyptratae show an unusual development of the tentorial thickenings in that they extend about the entire caudal/margin of the head. In some cases

these tentorial thickenings join with the occipital foramen as in *Calobata* (Fig. 114), *Scatophaga* (Fig. 135), *Heteroneura* (Fig. 116), *Lispa* (Fig. 116), and *Myiospila* (Fig. 127) while in *Musca* (Fig. 133), *Coelopa* (Fig. 121), *Hydrotaea* (Fig. 127), and others there is no connection.

The invaginations of the posterior arms of the tentorium of the *Acalyptratae* and the *Calyptratae* are located laterad or latero-ventrad of and adjacent to the occipital foramen. In many of the species figured the invaginations are merely long, heavily chitinized furrows extending latero-ventrad from the occipital foramen and very often it is difficult to definitely locate them.

Two mesal projections arise from the proximal portions of the posterior arms in a majority of the *Cyclorhapha*. In some species these structures are well developed and their mesal ends apparently join on the meson cephalad of the occipital foramen. These structures are similar to those described among the *Brachycera* and are the rudiments of the body of the tentorium.

No invaginations of the tentorium occur on the cephalic aspect in any of the forms which possess a ptilinum. On account of the decided specialization of this aspect, it is very difficult to know just what has happened. The tentorium is represented by thickenings which extend from the ventral to the cephalic aspect of the head. The extent of these thickenings varies; in some genera they continue to the antennal fossae while in others they are practically wanting.

The arrangement and structure of the movable parts of the head of the generalized Diptera are homologous with the corresponding arrangement and structure of the movable appendages of generalized insects. Among the Cyclorrhapha the parts retain their relative position, but structurally they undergo striking modifications and in some cases almost complete reduction.

In order to make use of a number of terms found in the following discussions, the mouth-parts as a whole will be considered at this point. The appendages of the mouth of the generalized Diptera are free, independent structures with their proximal ends adjacent to the head-capsule. The cardines and stipites of the maxillae are exceptions to the above in that they are imbedded in the mesal membranous area of the caudal aspect of the head. The mouth-parts, the labrum-epipharynx and the hypopharynx among the Calyptratae constitute a single complex mouth-appendage designated as the proboscis. The chitinized parts of the proboscis are far removed from the head-capsule, but in this projection of the parts, the proximal ends of the chitinized appendages are joined together and have the same relationship with each other as in generalized insects.

The term proboscis is most applicable among the Cyclorrhapha where the mouth-parts resemble the Calyptratae type. The proboscis naturally divides itself into three areas at the two places where it bends when it is withdrawn into the oral cavity. The three parts of the proboscis have been given varied and confusing names. Hewitt divides it into two general areas, the rostrum and the proboscis proper as follows; " The proboscis con-

sists of two parts, a proximal membranous conical portion, the rostrum and a distal half the proboscis proper which bears the oral lobes. The term haustellum is also used for this distal half (minus the oral lobes) and as a name it is probably more convenient, as the term proboscis is used for the whole structure, - rostrum, haustellum and oral lobes."

The terms rostrum and haustellum have been used in various ways by numerous workers in different orders; consequently the parts which they designate are by no means homologous. A more comprehensive set of terms based upon the word proboscis have been used by a few workers. They divide the proboscis into basiproboscis, mediproboscis and distiproboscis. These have been adopted. The basiproboscis is equivalent to the rostrum and may be defined as the membranous, cone-shaped area between the ventral margin of the head-capsule and the proximal ends of the theca. The tormae, labrum-epipharynx, hypopharynx and the maxillae are parts of the basiproboscis. The mediproboscis is the median section of the proboscis and includes the theca and the chitinized cephalic groove of the labium. It is equivalent to the haustellum of most authors. The distiproboscis is the enlarged dilated lobes at the distal end of the proboscis and is composed of the paraglossae, with their pseudotracheal areas, and the glossae. The distiproboscis is equivalent to the oral lobes or labellae. The movable appendages of the head have been discussed in the following order; antennae, mandibles, maxillae and labium.

Antennae.- The antenna of a generalized hypothetical dipterous head is many segmented and of a filiform type. All the segments are similar except the two large proximal ones known as the

scape and pedicle. The scape articulates with the chitinized antennal sclerites which bound the periphery of the antennal fossae that are located on the vertex dorsad of the arms of the epicranial suture. The antennae of the hypothetical type resemble the antennae of many generalized insects.

The antennae of the majority of the *Nemotocera* resemble the hypothetical type and on the whole resemble each other. The variations in the shape and size can be seen in the figures. Secondary sexual variation in a few of the *Nemotocera* where the antennae of the male, illustrated by *Chironomus* (Fig. 207) and *Isorophora* (Fig. 211), give rise to long flexible setae while those of the female are almost bare.

The antennae of the *Brachycera* show a wide range of development, however, the main line of specialization in the majority of the genera figured is toward the type found in *Lonchoptera* (Fig. 223) and *Dolichopus* (Fig. 226). One of the striking exceptions to this general line of development occurs in the geniculate type found in *Stratiomyia* (Fig. 213). The antennae of the *Brachycera* as a rule possess a smaller number of segments than the *Nemotocera*. The scape and pedicle only undergo a slight change in this group, but the flagellum is greatly modified. The proximal segment of the flagellum or the third segment of the antennae is enlarged while the remaining segments are reduced in size so as to resemble the lash of a whip. The lash-like portion of the antenna is called the arista. The following genera suggest the various stages thru which the antennae have passed to attain the muscid type of development. In *Tabanus* (Fig. 214), *Empis* (Fig. 215), *Exoprosopa* (Fig. 216), *Promachus* (Fig. 217), and *Leptis* (Fig. 218) the

flagellum is stylate in form and the third segment is large and conical in shape with one or more segments at its distal end. The antennae of *Platypeza* (Fig. 222), *Lonchoptera* (Fig. 223), *Aphiochaeta* (Fig. 224), *Oecothea* (Fig. 227) and *Dolichopus* (Fig. 226) show an advanced stage of development in which the third segment is large and round and the remaining segments are lash-like and located toward one side of the third segment. All but a few of the antennae of the *Cyclorhapha*^y have apparently developed from a type similar to the last mentioned genera. The principal differences between the antennae of this group occurs in the length and breadth of the third segment and in the modification of the arista. The antennae of *Olfersia* (Fig. 249) is a reduced muscid type, located in deep cavities on the cephalic aspect of the head; the scape and pedicle are greatly reduced and the arista is merely a small projection on the lateral aspect of the large segment.

Antennal sclerites are present only in *Chironomus* (Fig. 203) and *Psorophora* (Fig. 10 and 11). In these genera it is a distinct chitinized ring about the proximal end of the scape. The extent and location of the membrane with which the antennae are connected varies considerably. In *Trichocera* (Fig. 10), *Chironomus* (Fig. 12), *Psorophora* (Fig. 11), *Mycetobia* (Fig. 7.), and others it is very extensive.

A general survey of the antennae of the Diptera shows that among the *Hemiptera* they are generalized and on the whole resemble each other. The specialized antennae of the *Cyclorhapha* in all but a very few genera are of the muscid type and also quite similar in form. The antennae of the *Brachycera* present a few

specialized types, but the majority of them show intermediate stages between the forms found in the Nematocera and those of the Cyclorhapha.

Mandibles.- Only a few of the generalized Diptera possess mandibles. They are present in the female of *Simulium* (Fig. 2 and 250), *Tabanus* (Fig. 255 and 213), *Psorophora* (Fig. 159 and 251), *Culicoides* (Fig. 253), *Dixa* (Fig. 254), and *Bibliocephala* (Fig. 155 and 256) and wanting in the males of all species examined except *Simulium* (Fig. 3 and 252). The males of *Simulium johannseni* and *Simulium jenningsi* possess distinct mandibles. No other males of *Simulium* were observed. So far as known this is the first record of a male dipteran possessing true mandibles.

The hypothetical mandibles of a dipteran are long, thin, sword-shaped structures fitted for piercing. They would thus resemble the structure of the mandibles of *Tabanus* (Fig. 255) and *Culicoides* (Fig. 253). They are located between the clypeus, labrum-epipharynx and the maxillae, and are closely associated with the invaginations of the anterior arms of the tentorium. Structurally the hypothetical mandibles do not resemble the biting mandibles of the Orthoptera, but their location and their association with the invaginations of the anterior arms of the tentorium are the same. Their association with the invaginations of the anterior arms and their location is far more important in determining the homology of the mandibles than any particular form they may assume.

The mandibles vary in their structure. In *Psorophora* (Fig. 251) they are long and needle-like while in *Tabanus*, *Culicoides* and the male of *Simulium* (Fig. 252) they are sword shaped and are spindle-like in *Dixa* (Fig. 254.). The mandibles in the female of

Simulium (Fig. 250) are a trifle longer than those of the male (Fig. 252) and much broader at their distal ends. The greatest specialization in structure and point attachment with the head occurs in the long, thin, saw-like mandibles of Bibiocephala (Fig. 253) and Blepharocera. They are longer than the labium, blunt at the end, and toothed along the mesal margin and fit against a similar edge on the lateral margin of the hypopharynx.

All mandibles of the Diptera are connected with the head-capsule cephalad of the maxillae and caudad of the labrum-epipharynx and the fronto-clypeus. In this respect they resemble the hypothetical type. In Psorophora, Dixa, Simulium and Tabanus they are associated with the invaginations of the anterior arms of the tentorium. The proximal ends of the mandibles of Psorophora (Fig. 159) are bent cephalad and articulate with the head-capsule at the distal ends of the crescent-shaped thickenings which arise from the margins of the invaginations of the anterior arms of the tentorium. In Dixa the mandibles connect with the head-capsule at the ventro-caudal angles of the clypeus. An indistinct thickening extends dorsad from the point of articulation of each of the mandibles toward the invaginations of the anterior arms of the tentorium. The mandibles of Simulium (Fig. 250 and 251) and Tabanus (Fig. 317) connect with the head-capsule directly ventrad of the invaginations of the anterior arms, but no direct connection occurs between them. In the female of Simulium the mandibles articulate with a hook-shaped projection of the vertex. The mandibles of Tabanus (Fig. 255) are bifurcate at their proximal end and the lateral bifurcation articulates with the head. The location of the mandibles of Bibiocephala and Blepharocera is general-

ized in respect to their position between the maxillae and the fronto-clypeus, but their points of attachment with the head-capsule is decidedly specialized. They unite with chitinized pillars (Fig. 83) on the caudal aspect ventro-laterad of the invaginations of the posterior arms of the tentorium. The proximal portions of each mandible is a long chitinized strip imbedded in the membrane. These strips extend cephalad from their caudal connection to the cephalic margin of the membrane about the mouth-parts. At this point where distinct tendons are attached they turn abruptly ventrad and become free appendages. All connection between the mandibles and the invaginations of the anterior arms of the tentorium is lost. The relationship between the tentorium and the mandibles has not been observed in *Culicoides* for the lack of material. No other families of the Diptera outside of those to which the above named genera belong, so far as observed, possess true mandibles or rudiments of the same. When mandibles are present, they are always of considerable size and probably functional.

A number of investigators have described mandibles for many species not included in the above families. Langheffer (1888) describes mandibles for the Dolichopodidae (Fig. 304 and 308) which are shown in this paper to be modifications of the epipharynx. The apodemes of the muscids (Fig. 304, 308 and others) have been called mandibular tendons. This is incorrect as shown by the figures and discussion of the maxillae. A number of workers believe that the mandibles have united with the labium and exist as chitinized strips on the cephalic aspect of the labium or as thickenings on the meson of the theca. Neither of these interpre-

tations can be accepted when one takes into consideration the relative position of these so-called mandibles and the manner of development of the calyptrate proboscis. The chitinized thickenings on the cephalic aspect of the labium are located caudad of the maxillae and the hypopharynx. This does not agree with the location of the mandibles of any other insect. Furthermore these thickenings are present in *Tabanus* where true mandibles occur. The chitinized thickenings on the meson of the theca among some of the *Diptera* cannot be considered as rudiments of mandibles for many reasons. The most conclusive argument is in the fact that these thickenings are very prominent in *Simulium* where distinct mandibles are present in both sexes.

When interpreting mouth-appendages, it is always necessary to take into consideration the generalized relationship between the mouth-parts and their association with the invaginations of the tentorium. It is also very desirable to observe a large series of forms before attempting to homologize the parts. The above interpretations were apparently not made from either of these viewpoints.

Maxillae.- All *Diptera* having functional mouth-parts possess maxillae. They are, however, greatly reduced and modified in some genera and at first glance bear little or no relation to the structure or location of the maxillae of generalized *Diptera* or other insects. Numerous intermediate stages of maxillary development are present in the various species; consequently it is possible and in fact comparatively easy to trace thruout the order the main line of specialization and several side lines.

The hypothetical maxillae of the Diptera resemble the maxillae of a generalized insect in their homologous sclerites, their location between the mandibles and the labium and their close association with the invaginations of the posterior arms of the tentorium. Structurally they are composed of small, triangular cardines, long stipites, five segmented palpi, needle-like galeae and short laciniae. The cardines and stipites differ from those of generalized insects in that they are imbedded in the mesal membranous area ventrad of the occipital foramen. The palpi, galeae and laciniae are free appendages. The proximal ends of the cardines are adjacent to the invaginations of the posterior arms of the tentorium. The structure and location of the various parts of the hypothetical type have been traced thruout the order. The species in which the ptilinum is wanting are considered first.

The cardines are small distinct triangular sclerites in *Trichocera* (Fig. 260), *Rhyphus* (Fig. 261), *Dixa* (Fig. 262), and the female of *Tabanus* (Fig. 259). In these genera they are adjacent to the invaginations of the posterior arms of the tentorium. The cardines of *Simulium* (Fig. 258), male or female, differ from the above genera in that they are large and occupy nearly all of the membranous area between the postgenae dorsad of the stipites. Their margins are also somewhat indistinct. No other forms figured possess distinct sclerites that are homologous to the cardines of the hypothetical type. The maxillae of *Rhabdophaga* (Fig. 268), *Bibiodephala* (Fig. 269) and *Chironomus* (Fig. 270) connect with the invaginations of the posterior arms by means of narrow chitinized processes which arise from the stipites proper. Undoubtedly these pieces are reduced cardines which have lost the

suture that separates them from the stipites. The presence of this suture is suggested by the suture-like depression in the male of *Bibiocephala* (Fig. 76). Except for *Promachus* (Fig. 270) and the above forms, the cardo is wanting in all the maxillae figured. The maxillae of *Psychoda* (Fig. 263) and *Sciara* (Fig. 267) closely resemble some of the above maxillae, but the cardines as chitinized pieces are apparently wanting. A distinct membranous area exists between the proximal end of the stipites and the invaginations of the posterior arms of the tentorium. From forms such as these it is concluded that the cardines have been lost as chitinized areas. No other interpretation seems possible with the evidence at hand.

The stipites are of various shapes and sizes as can be seen in the figures. In *Rhabdophaga* (Fig. 268), *Bibiocephala* (Fig. 269), and *Chironomus* (Fig. 270) and possibly *Nycetobia* (Fig. 90) they have united to form a chitinized strip or plate in the membranous area dorsad of the labium. This piece should not be confused with the sub-mentum of the labium. The proximal end of the stipites are near the invaginations of the posterior arms of the tentorium in all species where the postgenae have not united ventrad of the occipital foramen. In species where the postgenae form a continuous chitinized plate, the stipites are reduced in size and located at or beyond the ventral margin of the head as in *Mydas* (Fig. 319) and *Eristalis* (Fig. 328). In other words the usual association between the maxillae and the invaginations of the posterior arms has been lost. *Psilocephala* (Fig. 281) and *Psorophora* (Fig. 96) are exceptions to the last statement. In *Psilocephala* chitinized thickenings are present on the ental sur-

face of the postgenae ventrad of the occipital foramen and these are undoubtedly rudiments of the stipites. The stipites of *Psorophora* are long free rod-like structures located entad of the postgenae. They extend between the occipital foramen and the ventral margin of the head. The stipites of *Geranomyia* (Fig. 385) and *Limnobia* (Fig. 386) are also entad of the postgenae. In these genera their proximal ends are united and they have no connection with the head-capsule. The stipites of *Tipula* (Fig. 277) resemble those of *Geranomyia* and *Limnobia*, but there is greater reduction in size and they are completely united along their mesal margins, thus forming a single median piece.

The maxillae of *Promachus* (Fig. 84) differ from all other genera in that the stipites and cardines are united on the meson and continuous with the postgenae near the occipital foramen. Narrow membranous areas separate the maxillae from the postgenae near the ventral margin of the head. This unique modification of the maxillae agrees with the striking modifications in the other mouth-parts.

The figures show the variations found in other genera belonging to this group. In general it can be said that the stipites have been modified by reduction and by removal to the ventral margin of the head and in some cases are even located on the basi-proboscis.

The maxillary palpi of the *Nemotocera* figured have from two segments, *Geranomyia* (Fig. 382) and the female of *Psorophora* (Fig. 261), to five segments. The usual number is four or five. In the *Drachycera* only one articulating segment is present. The articulating segment in *Tabanus* (Fig. 259) connects with an elongated

portion of the stipes which is called the palpifer by some workers. In this study the palpifer is considered as wanting since no palpus of the Diptera possesses over five segments and furthermore no piece is present at the base of any generalized palpus which can be homologized with the palpifer of generalized insects. The greatest reduction in the palpus of the ~~Nemotocera~~ occurs in *Ceratomyia* (Fig. 382), while in the Brachycera the palpus of *Hydas* (Fig. 271) is a mere lobe.

A small finger-like structure arises from the ventro-mesal margin of each stipes and projects mesad to the caudal aspect of the hypopharynx in *Tabanus* (Fig. 59) and *Simulium* (Fig. 258). This piece is apparently homologous with the lacinia of generalized insects. The distal end of this projection articulates against the caudal aspect of the hypopharynx and in this respect it differs from generalized insects. This piece in *Tabanus* has been described as ^{the} lacinia by Patton and Cragg (1913).

A distinct lobe is present mesad of the palpus in the majority of the Diptera that do not possess a ptilinum. This structure is unquestionably the galea, for in specialized insects which possess a distinct galea the lacinia is generally reduced in size and in some cases wanting. This tendency of development holds true with the Diptera. If the above pieces in *Tabanus* and *Simulium* which are described as lacinia, are true lacinia there can be no question regarding the interpretation of the lobe adjacent to the palpus. The galea vary considerably in size and shape. They are long and needle-like in *Tabanus*, the female of *Psorophora*, *Equis* (Fig. 274), and *Exoprosopa* (Fig. 285), while in *Trichocera* (Fig. 260), *Dixa* (Fig. 262), *Sciara* (Fig. 267), *Bittacomorpha*, *Chironomus* (Fig.

270), Lonchoptera (Fig. 280), Scenopinus (Fig. 282), and the male of Isorophora (Fig. 286) they are greatly reduced. In Bibio (Fig. 264) and Ceratomyia (Fig. 382) they are mere rudiments. They are wanting in Rhabdophaga (Fig. 268), Tipula (Fig. 277), Helobia (Fig. 385), Aphiochaeta (Fig. 278), Pijunculus (Fig. 279), Platypeza (Fig. 272) and Dolichopus (Fig. 284).

From this point the development of the maxillae of the genera possessing a ptilinum will be considered. No cardines or lacinia are present in this group. The maxillary palpi are one segmented and present in all forms except Conops (Fig. 305). The stipites and galeae are present in all the species studied and they undergo decided morphological changes. All connection or association between the maxillae and the invaginations of the posterior arms of the tentorium has been lost. This loss is even more pronounced than in the Brachycera since in all, but a few species figured the maxillae are far removed from the head and located near the distal end of the well developed basiproboscis. The removal of the maxillae among the Cyclorhapha has not altered their generalized position between the labrum, epipharynx and the labium.

The ^{stipes} of genera possessing a ptilinum show all stages of ingrowth from a turned in free edge or end, to forms where it is entirely ental of the membrane of the basiproboscis, as in Musca. Eristalis (Fig. 280) and Exoprosopa (Fig. 285) are the only forms without a ptilinum which show an ental growth of the stipes. These genera make a good starting point for explaining the characteristic development found in the Acalyptratae and the Calyptratae. The following scheme of lines and dots has been adopted on the drawings in order to show the degree of ingrowth of the stipes.

A continuous solid line on the stipes indicates a definite ectal boundary which connects with the membrane of the basiproboscis. A broken line indicates an ental edge or end which is free of the membrane between it and the observer. The membrane is represented by stippling. For convenience of description and homology the following divisions of the stipes has been made. St represents the ectal portion of the stipes and se the ental part. St is further divided into st-1 and st-2 as seen in *Coelopa*.

In *Exoprosopa* (Fig. 285) the distal end of the stipes is free and entad of the membrane while the cephalic edge and the dorsal end are entad in *Eristalis* (Fig. 286). From a form similar to *Eristalis* it is possible to develop a stipes which would resemble that of *Sepsis* (Fig. 287), *Coelopa* (Fig. 288), and *Calobata* (Fig. 296). In *Sepsis* the palpus is greatly reduced, but it connects with an ectal portion^t of the stipes (st) which in turn gives rise to the free ental portion (se). The free ental part extends ventrad and is continuous with the galea which emerges from the membrane near the base of the labrum as a free appendage. The stipes of *Coelopa* (Fig. 288), *Sapromyza* (Fig. 289), and *Sphyracephala* (Fig. 293) is similar to *Sepsis*, but in these forms the palpus arises from the cephalic margin of the basiproboscis. The palpus is connected with the stipes proper by means of long chitinized strip (st-1) which is usually covered with setae. This ectal portion of the stipes (st-1) is present in all but a few genera such as *Chloropisca*, (Fig. 306), *Heteroneura* (Fig. 298), *Chatomya* (Fig. 299), *Loxocera* (Fig. 300), and *Euaresta* (Fig. 292). In a number of forms, particularly the *Calyptratae*, a small chitinized area is present ventrad of the palpus. This is considered as a second-

dary chitization. The ectal portion of the stipes which is labelled st-2 is present in the majority of the Acalyptratae and in one or two of the Calyptratae.

The ental portion of the stipes (se) is always present in the members of this group. In *Desmometopa* (Fig. 303), *Chloropisca* (Fig. 306), *Conops* (Fig. 305), and the Calyptratae it has no connection with the ectal portion of the stipes (st-2) and is commonly designated as the apodeme by many writers. The free so-called apodeme is unquestionably derived from the ental ingrowth of the stipes as illustrated by the modifications found in the following genera, *Coelopa* (Fig. 288), *Sapromyza* (Fig. 289), *Tetanocera* (Fig. 297), *Archytas* (Fig. 309), *Musca* (Fig. 304) and others.

The development of the galea may be traced thruout the Cyclorhapha in a manner similar to that of the stipes. In *Eristalis* (Fig. 286) the galea is a long free appendage arising from the ventral end of the stipes near the proximal end of the labrum-epipharynx. In its ventral extension it is adjacent to the lateral margins of the labrum-epipharynx. Its length and size is greatly reduced in *Sepsis* (Fig. 287), but its location is identical with that of *Eristalis*. Thruout the majority of the Acalyptratae the location of the galea resembles that of *Sepsis*. Its size and form undergoes some change as can be seen in the figures. Among the Calyptratae and in some of the Acalyptratae the galea articulates with the proximal end of the labrum and is more or less firmly connected with the same. The ectal exposure of the galea is very small in these forms. The large galea of the Acalyptratae has been considered as labial palpus by a few workers. This interpretation is highly improbable.

Labium.- The labium is the most specialized and characteristic appendage of the mouth of Diptera. Its structural modifications are very striking among the specialized genera such as the *Cyclorhapha*. These modifications are largely due to the reduction of parts and to the excessive development of membranous areas and agree with similar type of modification in other head and mouth-parts.

In order to explain the unique development of the labium of the Diptera, it has been necessary to make a critical study of the generalized condition of this appendage as it occurs in the *Nemotocera* and to carefully compare it with the labia of more generalized insects. As is well known the labium of a generalized insect is the posterior, independent, flap-like mouth-part and it is made up of a submentum, mentum and ligula. The ligula is further divided into a proximal area which gives rise to palpi-gers, palpi, paraglossae and glossae. The labium of a generalized dipteran resembles that of a generalized insect in its caudal position and in its independent condition, it is very different in structure. It is more or less enlarged and not flat and flap-like and the palpi and palpi-gers are always wanting, so far as observed. Since the location of the palpi and the palpi-gers is very important in generalized insects in orienting the sclerites of the labium, their absence in Diptera makes it exceedingly difficult to correctly homologize and locate the submentum, mentum and the parts of the ligula. The membranous condition of the labium also adds to this difficulty.

In order to get some light on this problem, a study was made of the labium, particularly the submentum and mentum, of a num-

ber of generalized insects of the more common orders. The literature on this subject was examined, but no satisfactory results were obtained from this source. After a careful study of a number of labia, the following general facts which bear upon the labium of Diptera, were noted. The submentum is the large proximal segment, while the mentum is usually small and in some cases very thinly chitinized and almost obsolete. The sutures separating the mentum from the submentum and the ligula are only represented by small remnants in *Melanoplus*. The ligula, so far as observed, is the movable part of the labium while the mentum and submentum are more or less firmly united with the head-capsule. The proximal part of the ligula is usually well developed and gives rise to the palpigers, palpi, paraglossae and glossae. The glossae are located between the paraglossae and in number of forms it was observed that a distinct depression or thickening extended proximad between the glossae and the proximal margin of the ligula.

With these interpretations as a basis for comparison, the labium of such generalized Diptera as *Chironomus* (Fig. 371), *Simulium* (Fig. 366), *Trichocera* (Fig. 365), *Dixa* (Fig. 375) and others may be interpreted as follows. The mesal membranous area of the caudal aspect of the head, which is bounded by the postgenae, the occipital foramen, and the proximal chitinized piece of the labium, is made up of the submentum, mentum and the cardines and stipites of the maxillae. Since this area is largely membranous, it is impossible to determine the boundaries of these sclerites. The areas laterad of the cardines and stipites apparently belong to the maxillae, while the area mesad of these parts is made up

of the submentum and mentum. The important feature concerning this mesal membranous area is the fact that the maxillae and labium both play a part in its constitution. This undoubtedly indicates that the more or less fixed nature of the submentum and mentum among generalized insects has been increased and more extensively developed in the Diptera and the submentum and mentum are included with the membrane developed from the stipites and cardines. Such an interpretation is altogether possible since the proximal portions of the maxillae are adjacent to the submentum and mentum in generalized insects.

The ligula of the generalized Diptera agrees with the ligula of generalized insects in that it is the movable part of the labium. Structurally it is composed of a well developed proximal area which gives rise to two large bulb-like paraglossae and to two small membranous glossae which are located between the paraglossae. The palpigers and labial palpi are wanting but, if in the future some form is discovered which shows these structures, they will be undoubtedly found on the area here described as ^{the} ligula. The proximal portion of the ligula has a decided furrow or thickening on its caudal aspect along the meson. This thickening is characteristic of a large number of Diptera and in this respect resembles the proximal portion of the ligula of a number of generalized insects. This mesal thickening marks the line of fusion of the two parts of the labium during embryonic development.

The above interpretation of the labium is on the whole very satisfactory for the numerous modified types in the various families. It is possible upon the above interpretation to formulate an hypothetical labium. This has been done, but there has been

added to this labium the early stages of development of the more important secondary structures which are characteristic of the labia of Diptera. It would be advisable to call such an hypothetical labium a typical labium in order to differentiate it from a true hypothetical type as used in other parts of this study.

A typical labium of the Diptera is made up of the following parts. The submentum and mentum are firmly united with the head and constitute the greater portion of the mesal membranous area of the caudal aspect of the head. The ligula or mediproboscis and distiproboscis is the large swollen and movable portion of the labium and is composed of a proximal portion which has on its caudal aspect a distinct chitinized area, commonly called the theca, and two large membranous bulb-like paraglossae and two small membranous glossae located between the proximal parts of the paraglossae. The important and characteristic features of a typical labium are the chitinized pieces on the caudal and lateral aspects of the paraglossae and the tracheal-like structures on the mesal aspects. The details of the various parts will be more fully discussed as each part is considered and its modifications traced thruout the order.

The submentum and mentum are present as a membranous area in the majority of the Nemotocera and in the female of *Tabanus* (Fig. 74). This area undergoes considerable modification as was seen in the discussion of the maxillae and the postgenae and illustrated by the figures. *Rhyphus* (Fig. 80 and 374) is apparently the only genus which possesses a chitinization within this area that cannot be considered as a modification of the maxillae or the postgenae. This chitinized piece is a more or less indistinct-

ly chitinized, inverted flask-shaped area located between the maxillae. If this is a primary chitinization, it is more likely a remnant of the submentum. A similarly located area may be found in *Mycetobia* which has been homologized by some writers with that of *Rhyphus*. This interpretation is undoubtedly incorrect, since this area in *Mycetobia* (Fig. 90) gives rise to chitinized projections at its ventro-lateral angles and these in turn connect with the maxillary palpi and the galeae. Furthermore the relationship which this piece bears with the proximal end of the theca, would tend to disprove such an interpretation. This piece in *Mycetobia* is undoubtedly a ~~specialization~~ a specialization of the maxillae similar to the modifications found in *Bibiocephala* (Fig. 87) and *Rhabdophaga* (Fig. 80). In all genera where the postgenae have grown together on the meson, the submentum and mentum have been eliminated unless one wishes to consider the area between the ventral margin of the head and the theca as derived from these areas. This area, as already described for the *Cyclorhapha* is very extensive and forms the caudal portion of the basiproboscis.

The proximal portion of the ligula or mediproboscis of the typical type of labium is largely membranous, but it possesses on its caudal aspect a distinct chitinized area, the theca, which has a distinct furrow on its meson. The shape, size and the degree of chitinization of the theca varies greatly as can be seen in *Bibio* (Fig. 364), *Trichocera* (Fig. 365), *Rhyphus* (Fig. 374), *Fromachus* (Fig. 376), *Tabanus* (Fig. 391), *Chironomya* (Fig. 411), *Conops* (Fig. 420), *Phaenomyia* (Fig. 424), and *Musca* (Fig. 466). A distinct furrow or thickening is present on the meson of the majority of the ~~Nemotocera~~ and the *Brachycera* and reman-

ants of these thickenings also occur among the *Cyclorhapha*. In some of the genera of *Diptera* the structural condition of the meson has a marked influence on the shape of the dorsal and ventral margin of the theca. The cephalic aspect of the proximal portion of the ligula of a typical labium is concave and membranous and connects with the proximal part of the lance-like portion of the hypopharynx. In the *Hemitecera* the cephalic aspect resembles the typical labium and in the *Brachycera* and the most of the *Cyclorhapha* it possesses a distinctly chitinized groove. This is well illustrated by *Tabanus* (Fig. 392), *Eristalis* and the majority of the *Calyptratae*. The degree of chitinization varies considerably and in some forms heavy chitinized cord-like pieces extend along the sides of the groove from the glossae to the proximal end of the labium.

The distiproboscis of the typical labium is composed of two large, independent, highly membranous, bulb-like paraglossae usually called oral lobes or labellae and two, small membranous glossae. Each paraglossa has on its lateral and caudal aspects a Y-shaped chitinized support which has been commonly called the furca. For convenience in description and as an aid in tracing the development of the parts of the furca thruout the order, it has been divided into furca-1 which is the stem of the Y, furca-2 which is the dorsal arm of the Y and furca-3 which is the ventral arm. The furca articulates against a small sclerite which is located between the proximal end of furca-1 and the distal end of the chitinized furrow on the meson of the theca. This piece has been given the name of sigma. Another small, independent sclerite is located in the membrane just laterad of

the sigma and may be known as kappa. Each paraglossa has on its mesal aspect two trachea-like structures which arise from the proximal portion of the glossa. These structures are commonly designated as pseudotracheae.

A general survey of the characteristics of the paraglossae of the various labia shows that they are usually bulb-like, membranous, and somewhat flexible. In these respects they differ decidedly from the firmly chitinized, flap-like labia of many generalized insects. Their size and shape varies greatly as can be seen in *Biblio* (Fig. 364), *Leia* (Fig. 368), *Promachus* (Fig. 376), *Ceranomyia* (Fig. 382), *Tipula* (Fig. 384), *Tabanus* (Fig. 390), *Conops* (Fig. 417), *Empis* (Fig. 421), *Siphona* (Fig. 458), *Musca* (Fig. 467), *Stomoxys* (Fig. 479) and *Olfersia* (Fig. 488). The use to which the labia are put seems to have some influence on its form. The main line of development thruout the genera figured is toward a Calyptratae type, where they are usually large, decidedly membranous, and joined together on the dorso-caudal areas as in *Hydrotaea*^a (Fig. 475), *Sarcophaga* (Fig. 477), *Loxocera* (Fig. 461), *Sepsis* (Fig. 439), *Tetanocera* (Fig. 463) and many others.

The membranous development of the paraglossae is not always a good indication of a calyptrate type of specialization. In a number of scattered genera, *Chironomus*, *Ephyphus*, *Aphiochacta*, *Chloropisca*, *Platypeza*, *Leptis*, *Psilocephala*, and *Lonchoptera*, it is next to impossible to make out the chitinized pieces such as the kappae, sigmae and furcae because of the membranous condition of the entire labium. Outside of the above named forms, the chitinized pieces of the paraglossae are distinct. These supports may be secondary in origin or they may be remnants^a of

former chitinized parts of the paraglossae. It is possible to show how the various chitinized pieces of the majority of the labia may have developed from the typical type.

The sclerite designated as kappa on the typical labium is only present in *Tabanus* (Fig. 390 and 391), *Tipula* (Fig. 388), and *Bittacomorpha* (Fig. 85). No other dipteran gives any evidence whatsoever of such a sclerite. In the above mentioned genera the pieces are embedded in the membrane laterad of the ventral ends of the theca. Someone has interpreted these pieces as rudimentary palpigers or labial palpi. This may or may not be correct. So far as their position is concerned, it would be possible to have palpi in such a location. Since no other genera possess similar pieces and since they are so decidedly dissimilar to labial palpi and palpigers of generalized insects they are considered as ~~be~~ secondary sclerites.

The sclerite designated as sigma is present as a chitinized thickening at the ventral end of the theca as in *Eristalis* (Fig. 443) or as a distinct piece in the majority of the Brachycera and the Cyclorhapha. In all genera they are located between the ventral margin of the theca and the furca. Only a few genera of the Hemiptera such as *Tipula* (Fig. 388) and *Psorophora* (Fig. 380) possess these sclerites. They undergo some modification in size and structure as can be seen in the following genera, *Tabanus* (Fig. 391), *Mydas* (Fig. 397), *Conops* (Fig. 418), *Borborus* (Fig. 437), *Eristalis* (Fig. 443), *Coelopa* (Fig. 448) and *Scatophaga* (Fig. 470).

The furca of *Bibio* (Fig. 315) and *Tabanus* (Fig. 317) resembles closely the typical type. In *Bibio* furca-1 and furca-2 are

one continuous piece while furca-3 is a distinct arm. Furca-2 and furca-3 in *Tabanus* are distinctly chitinized areas arising from the distal end of furca-1. Only one chitinized support is present in *Sciara* (Fig. 314), *Rhabdophaga* (Fig. 313), *Psychoda* (Fig. 318), *Stratiomyia* (Fig. 331) and *Trichocera* (Fig. 311). In *Trichocera* this support has a decided dorsal bend near the constriction of the paraglossae. This bend is also present in *Psychoda* and *Stratiomyia*, but the constriction is wanting. The distal portion of the furca beyond the bend is homologous with furca-2, and furca-3 is wanting in these forms. Furca- is present and furca-3 is wanting in *Scenopinus*; furca-3, however, is present in more species than furca-2. Such is the case with *Borborus* (Fig. 342), *Chrysomya* (Fig. 341), *Coelopa* (Fig. 337), *Tetanocera* (Fig. 344), *Scatophaga* (Fig. 357), *Musca* (Fig. 351), and *Thelaira* (Fig. 346).

Furca-1 varies considerably thruout the order. In generalized forms where the dorso-caudal portions of the paraglossae are not joined together the furcae are always well separated. They are also separated in some forms where the paraglossae are joined as in *Mydas* (Fig. 397) and *Eristalis* (Fig. 443). In *Chrysomya* (Fig. 411), *Drosophila* (Fig. 454), *Tetanocera* (Fig. 463), and *Sepsis* (Fig. 439), an intermediate piece joins the mesal ends of furcae-1 while in *Sarcophaga* (Fig. 477), *Musca* (Fig. 466), *Coelopa* (Fig. 448), *Sapromyza* (Fig. 409), *Chrysomya* (Fig. 451), *Heteroneura* (Fig. 459) and *Oeciothea* (Fig. 452) furcae-1 are united and form one continuous U-shaped piece. This type of furcae is present among the *Calyptratae*. The furcae of specialized forms such as *Olfersia* (Fig. 488), *Conops* (Fig. 418), *Siphona*

(Fig. 355), Empis (Fig. 421), and others are not differentiated since the greater part of the lateral aspects of the paraglossae are chitinized.

In the typical labium two simple trachea-like structures, commonly known as pseudotracheae, arise from the proximal part of each glossa and extend onto the mesal membranous aspect of each paraglossa. These trachea-like structures are in reality small chitinized troughs which serve as conduits for the liquid food. Pseudotracheae are unique structures and peculiar to Diptera so far as known. They are present in only a few generalized forms and from these genera it is possible to develop the pseudotracheal arrangement and structure of the more specialized Diptera. Since this is possible, it is assumed that the pseudotracheae ^{probably arisen} have ^{only} ~~arise~~ once within the order and this took place sometime after the group as a whole was set off as a distinct order.

The pseudotracheae of Tipula (Fig. 383) resemble the hypothetical type in that the two main pseudotracheae arise from each glossa and extend over the mesal membranous area of each paraglossa, one of the pseudotracheae extends caudad and the other cephalad. These ducts are secondarily branched and resemble a fern. The pseudotracheae of Mycetophila (Fig. 607) and Leia (Fig. 368) are reduced and only the caudal pseudotracheae extend over the paraglossae. The paraglossae in these genera are united along their meson and form a single large lobe. The cephalic pseudotracheae are indicated by small rudiments in Mycetophila. The pseudotracheae in these forms resemble the typical type in that they are simple, unbranched, chitinized troughs. From the

typical type or from the conditions of the pseudotracheae as they occur in *Tipula*, it is possible to derive the arrangement and structure of the pseudotracheae as they may be found in *Tabanus* (Fig. 390) and similar forms where the two, long pseudotracheal trunks extend cephalad and caudad from each glossa and give rise to many branches on their ventral side. These branches extend ventrad over the entire mesal area of the paraglossa. The arrangement of the pseudotracheae of most ~~all~~ Diptera is readily derived from a type similar to *Tabanus*. The arrangement in *Scenopinus* (Fig. 400), *Psilöcephala* (Fig. 403) and the *Calyptratae* resembles *Tabanus*. In genera such as *Stratiomyia* (Fig. 396), *Oeciothea* (Fig. 453), *Coelopa* (Fig. 449), *Heteroneura* (Fig. 460) and others, no collecting ducts extend beyond the glossae. In many genera such as *Chloropisca* (Fig. 431) and *Chrysomya* (Fig. 412) no line of demarcation can be drawn between the ^{proximal ends} ~~base~~ of the pseudotracheae and the glossae.

U-shaped or open ring-like thickenings are present in the pseudotracheae of the more specialized Diptera. They do not occur in the simple pseudotracheae of *Mycetophila* or in some of the highly specialized forms. The histological structure of a pseudotrachea has been clearly demonstrated by several workers, according to Dimmock, "The pseudotracheae on the inner surfaces of the labellae of *Musca* are cylindrical channels, sunk, more or less deeply into the surface of the labellae, according to the amount that that surface is inflated, and they open on the surface in zig-zag slits. These channels are held open by partial rings, more strongly chitinized than the rest of the membrane of the cylinder. As seen from above in *Musca*, (Fig. 485), the pseudotracheae appear to

be supported by partial rings, one end of each of which is forked¹⁷.

**** The pseudotracheae of *Eristalis* are so nearly like those of *Musca vomitoria* that I have not figured those of the former." All observations made on the histological structure of pseudotracheae agree with those made by Dimmock. An attempt was made to work^{out} the detail of the histological structure in the various genera studied, however, a number of interesting facts were observed. The chitinized taenidia-like thickenings in *Cnethera* (Fig. 445 and 483) are large U-shaped structures which are partially embedded in the membrane. The ends of the U-shaped thickenings project to a considerable extent beyond the surface of the membrane and resemble these structures in *Bombylius major* (Fig. 482) as figured by Dimmock. The pseudotracheae of *Calobata* (Fig. 446) have developed into rows of small chitinized teeth.

The pseudotracheal area of the paraglossae undergoes its greatest specialization in forms where the paraglossae assume a biting function. This biting type is brought about by the development of distinct chitinized teeth arising between the proximal ends of the pseudotracheae. Rudimentary or well developed teeth occur in *Musca* (Fig. 467), *Sarcophaga* (Fig. 478), *Scatophaga* (Fig. 472), *Lispa* (Fig. 481) and *Stomoxys* (Fig. 479). In *Musca* the small chitinized so-called prestomal teeth are present between the proximal ends of the pseudotracheae. In *Scatophaga* and *Lispa* these teeth are large and distinct. Their greatest development occurs in *Stomoxys* and so far as observed the pseudotracheae are wanting in this form. A ~~more~~ extensive discussion of the development and structure of the chitinized teeth of the paraglossae has been given by Patton and Cragg (1913).

The glossae of a typical labium are two small lobes located between the proximal portions of the paraglossae distad of the furrow on the theca and at the distal end of the cephalic groove. Thruout the order the glossae are between the paraglossae and at the distal end of the cephalic groove. They are npt well defined structures in all labia. In Chironomus (Fig. 371) they are two small membranous lobes while in Simulium (Fig. 366), Rhabdophaga (Fig. 367), Bibio (Fig. 364), and Rhyphus (Fig. 374) they are in the form of a single median membranous lobe. The glossae of Simulium are of particular interest since they possess a great number of minute, chitinized thickenings which radiate from the proximal end. So far as known these thickenings bear no relation to the pseudotracheae of the paraglossae. The glossae of Tabanus (Fig. 391) are united and form a chitinized tridentate piece with the median tooth the longest. The glossae of Lonchoptera (Fig. 407) illustrate an intermediate form between a median spine as occurs in Psorophora (Fig. 381), Aphiochaeta (Fig. 393), Empis (Fig. 422) and Exoprosopa (Fig. 426), and a U-shaped structure which is so characteristic^s of the Cyclorrhapha. The glossae of the Calyptratae resemble in general the glossae of Musca (Fig. 465). In the genera of this group the cephalic ends of the U-shaped piece are free and project cephalad from the point of attachment of the pseudotracheae. The glossae are not well defined in a few genera, such as Sapromyza (Fig. 410), Chloropisca (Fig. 431), and Chomya (Fig. 412) and it is impossible to differentiate the glossae from the chitinized groove of the mediproboscis and the proximal ends of the pseudotracheae. The glossae of Pro-machus (Fig. 479) are specialized in that they give rise to two

thickenings which extend dorsad in the groove of the labium and serve as guides for the hypopharynx and galeae.

VII. EPIPHARYNX AND HYPOPHARYNX.

The anterior end of the alimentary canal of the Orthoptera and insects in general is divided transversely into two parts, one forms the cuticular lining of the clypeus and labrum and the other forms the lining of the opposite side of the mouth cavity. The portion lining the clypeus and labrum is known as the epipharynx and the opposite side as the hypopharynx. Each lining may be subdivided into several parts. These are of particular significance in the study of the epipharynx, which possesses a distinct, chitinized mesal piece and two lateral, chitinized pieces which are located near the clypeo-labral suture. These lateral pieces, which have been designated as tormae and so far as known are described here for the first time, project cephalad toward the clypeo-labral suture in *Melanoplus* and *Cryllus* and connect with both the labrum and clypeus. In *Cryllus* (Fig. 516) they are interpolated between the clypeus and the labrum and appear as small triangular sclerites on the cephalic aspect. The tormae of *Periplaneta* (Fig. 514) are not as well developed as in the above named genera, but they are present and project toward the cephalo-lateral corners of the labrum. The caudal end of the epipharynx in many insects gives rise to long chitinized arms which have been called cornua. The hypopharynx may be subdivided into a distal, unpaired, median piece which is usually called the hypopharynx and a proximal paired area.

The chitinized portion of the anterior end of the alimentary canal of Diptera can be homologized with the epipharynx and the

hypopharynx of generalized insects. The following hypothetical epipharynx and hypopharynx and their closely associated parts have been constructed for Diptera. In the figures of the lateral view of the hypothetical type an enlarged, three-sided chitinized tube extends caudad from the dorsal end of the hypopharynx and the epipharynx and has been called the oesophageal pump. This is not a part of the epipharynx or the hypopharynx but, is a modification of the pharynx, a portion of the alimentary canal. All of the chitinized parts ventrad of the membranous area at the cephalic end of the oesophageal pump belong to the epipharynx and the hypopharynx. The dorsal ends of the epipharynx and hypopharynx are united and form a single chitinized tube and this has been designated as the basipharynx. Except for this union, the epipharynx and hypopharynx are continuous chitinized pieces with their distal ends lance-like. The distal portion of the epipharynx is joined to the labrum by a membrane along its lateral margins. The tormae in the hypothetical type project from the lateral margins of the epipharynx and unite with the latero-ventral portions of the fronto-clypeus. Two projections occur at the dorsal end of the basipharynx and these are considered homologous with the cornua of the epipharynx of generalized insects. The distal end of the hypopharynx is a free lance-like organ and a salivary duct enters its proximal end just dorsad of the place where it joins the labium. The salivary duct extends thru the hypopharynx to its distal end.

The oesophageal pump of the alimentary canal is closely associated with the epipharynx and hypopharynx in all the Nemotocera and in *Prorachus* (Fig. 517), *Tabanus* (Fig. 494), *Leptis* (Fig. 530),

and *Psilocephala* (Fig. 533) of the Brachycera. In the majority of the above forms, the oesophageal pump is an elastic, semi-chitinized, three-sided tube with muscles connecting with each of its surfaces. The muscles on contraction expand the tube and upon relaxation the tube assumes its normal shape. In some forms as *Tabanus* and *Promachus* there is only one chitinized, elastic surface. In a number of genera as *Chironomus* (Fig. 531), *Psychoda* (Fig. 529), and *Leptis* (Fig. 530) the tube is more or less membranous and not distinctly three-sided. The oesophageal pump is wanting in all the Diptera except those named and the membranous oesophagus connects directly with the basipharynx in all other genera examined. The oesophageal pump shows considerable variation in its shape, position and size as can be seen in the figures of *Bibiò* (Fig. 520), *Rhyphus* (Fig. 508) and others.

The basipharynx is interpreted as including all of the united portions of the epipharynx and hypopharynx but the extent of this union varies somewhat in the different genera. Among the majority of the Nemotocera no sutures or constrictions occur between the basipharynx and the lance-like portions of the epipharynx and the hypopharynx. Constrictions and secondary sutures do occur in the majority of the Brachycera, as *Leptis* (Fig. 520), *Promachus*, and in all of the Cyclorrhapha. The basipharynx varies in size, and shape as can be seen in the figures. Muscles connect with the cephalic and caudal aspects of the basipharynx, those on the cephalic aspect expand the basipharynx and thus bring about suction. This sucking apparatus is well developed in all forms which do not possess an oesophageal pump. The chitinized projections at the dorsal end of the basipharynx, designated as the cornua,

vary in shape and size. Some are blunt, others long and narrow as in *Leptis* and the *Calyptratae*, and others are disk-shaped as in *Promachus* (Fig. 517).

Distinct tormae are present in *Diptera* except a few species of the *Nemotocera*. In all the *Nemotocera* and in *Leptis* (Fig. 520), *Psilocephala* (Fig. 533), *Platypeza* (Fig. 543), *Aphiochaeta* (Fig. 544), *Lonchoptera* (Fig. 539), and *Scenopinus* (Fig. 538), they resemble the hypothetical type in that they join with the fronto-clypeus. In all other genera the tormae have an exposed portion located ventrad of the fronto-clypeus and all connection between the fronto-clypeus and the tormae is lost, except in *Simulium* (Fig. 497) and *Tabanus*. The variations in the shape and extent of the tormae is well illustrated by the numerous figures. The so-called fulcrum described by numerous morphologists for the *Calyptratae* is therefore composed of the tormae and the basipharynx. A more or less distinct secondary suture is indicated in the drawings as separating the tormae from the basipharynx and the broken line on the tormae indicating the place of connection of the membrane of the basiproboscis with the tormae. This same line in the *Nemotocera* and the forms which have the tormae connecting with the fronto-clypeus also indicates the place of union between these parts.

The epipharynx is present and closely associated with the labrum in all *Diptera* having functional mouth-parts. The interrelationship between the epipharynx and the labrum has been discussed under labrum. The epipharynx in a number of generalized *Diptera* such as *Tabanus* (Fig. 494), *Simulium* (Fig. 497), *Dixa* (Fig. 501), *Limnobia* (Fig. 507), *Sciara* (Fig. 513), and others, resem-

bles the hypothetical type. In the majority of the Diptera it differs from the hypothetical type in that it is completely separated from the basipharynx by a constriction or a secondary suture. This hinge in the epipharynx permits the proboscis to bend at this point when it is withdrawn into the oral cavity. The lance-like portion of the epipharynx among the Calyptratae and other forms is completely separated from the basipharynx by the development of a special piece which is commonly called the hyoid. The lance-like portion of the hypopharynx also articulates against the hyoid. The hyoid is a secondary ^{sclerite} ~~suture~~ which originated from the epipharynx or the hypopharynx and serves the purpose of keeping open the alimentary canal which passes thru it. A structure, similar to the hyoid of *Musca* (Fig. 600), is found in *Stomoxys* (Fig. 599) where a large and strong trachea-like tube extends between the dorsal ends of the lance-like portions of the epipharynx, hypopharynx, and the basipharynx.

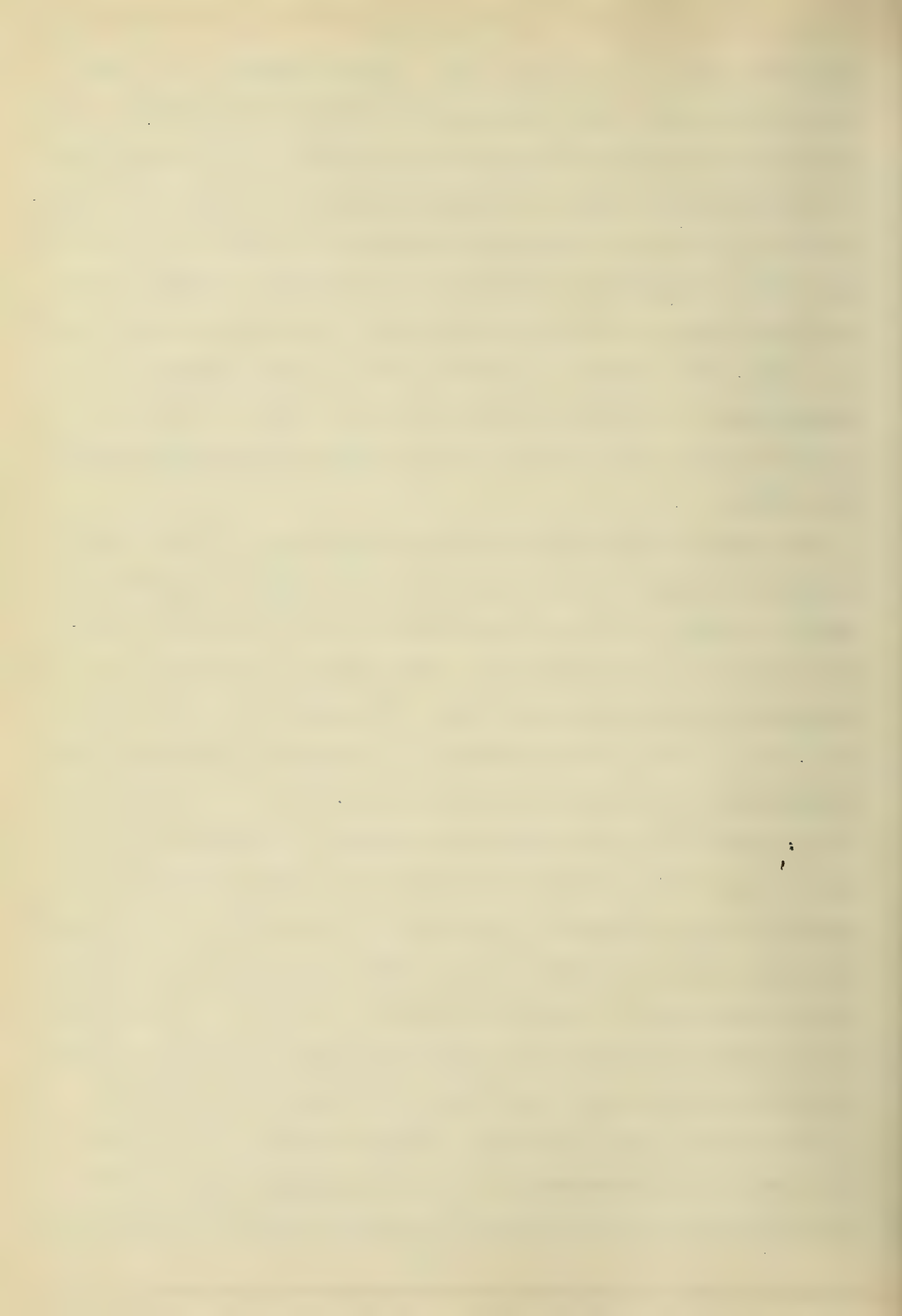
The size and shape of the epipharynx corresponds more or less closely with that of the labrum. The epipharynx as a rule in sucking Diptera is long and needle-like while in other forms it is usually short and blunt. In a number of the genera of the Acalyptratae the epipharynx has a secondary transverse suture near its distal end, as in *Sepsis* (Fig. 583), *Eristalis* (Fig. 588) and many others.

A few genera show special modifications of the epipharynx. This is particularly true of *Dolichopus* (Fig. 524 and 528). In this genus the epipharynx closely resemble the hypothetical type in the possession of a distinct membrane between the labrum and the epipharynx. The specialization of the epipharynx occurs in

the bifurcation of its distal end and the presence of a long club-shaped piece which projects from its meson dorsad into the cavity formed by the basipharynx, the tormae and the fronto-clypeus. These modifications are peculiar to this family. The bifurcations at the distal end are of particular interest in that they have been interpreted as mandibles by Langhoffer (1888). They are much larger in some of the genera of the Dolichopodidae than in others. The lateral and caudal views of the epipharynx and hypopharynx of Dolichopus show clearly the relation these projections have to the other parts and justify the interpretation here given.

The single, median, distal, lance-like portion of the hypopharynx is present in all but a few of the genera studied. The cephalic aspect of the labium usually connects with the lance-like portion of the hypopharynx just ventrad of the point of entrance of the salivary duct. In a few cases, as in Forborus (Fig. 565 to 567), the hypopharynx is completely fused with the labium, while in others, as Euaresta (Fig. 572), it is nearly so. In the majority of the genera the secondary separation of the lance-like portion of the hypopharynx from the basipharynx corresponds with the similar separation in the epipharynx. The shape and size of the hypopharynx also varies considerably as can be seen in the figures. In the mouth-parts fitted for sucking and piercing the hypopharynx is usually long and needle-like, while in licking types, most Calyptratae, it is greatly reduced.

The salivary duct enters the proximal portion of the lance-like part of the hypopharynx and in most cases before entering it continues as a duct or groove along its cephalic aspect. The



course of this duct or groove is indicated in the figures of the caudal aspect of the hypopharynx by broken lines. The salivary duct before entering the hypopharynx is enlarged and bulb-like in many species. In *Tabanus* (Fig. 494) the salivary bulb is a chitinized structure continuous with the hypopharynx while in *Promachus* (Fig. 517) it is chitinized, but separated from the hypopharynx. A chitinized bulb and an enlarged membranous swelling are both present in *Dolichopus* (Fig. 528).

The peculiar epipharynx and hypopharynx of *Olfersia* (Fig. 606) can be homologized with the more common types found thruout the order. The principal difference is in the shape and position of the basipharynx, tormae and the hyoid. The two lance-like structures embedded in the deep membranous depression about the oral cavity are the labrum-epipharynx and the lance-like part of the hypopharynx. The long crescent-shaped piece which extends cephalad from the proximal end of the labrum-epipharynx to the pear-shaped piece is homologous with the hyoid, and the pear-shaped piece with which the hyoid connects is composed of the tormae and the basipharynx. The exposed parts in the membrane ventrad of the head ^{are} ~~are~~ very small in this genus.

Only rudiments of mouth-parts occur in the head of *Gastrophilus* (Fig. 490 to 492). The anterior end of the alimentary canal is a simple chitinized tube which leads to the small opening on the ventral aspect of the head. This tube undoubtedly originated from the epipharynx and the hypopharynx. The mouth-parts are greatly reduced or wanting. It is possible that the small bulb-like structures located latero-caudad of the opening are remnants of the labium. It is impossible to homologize the other

minute modifications surrounding the mouth-opening.

In the Cyrtidae, as Oncodes (Fig. 139, 486 and 487), the mouth-parts show a greater reduction than in Gastrophilus. A chitinized ring is present in the membrane which covers the oral cavity and a broad plate extends dorsad from its caudal margin which gives rise to a small membranous tube, the oesophagus, which has no opening to the exterior so far as could be determined. It is impossible to homologize the parts within the oral cavity. The ental plate which gives rise to the oesophagus may be homologous with the basal portion of the epipharynx and the hypopharynx.

A general survey of the epipharynx and hypopharynx shows that the relationship between these parts and the head-capsule corresponds with the relationship between the mouth-parts and the head. Since the epipharynx and the hypopharynx are always connected with the labrum and the proximal part of the labium^b, they are projected ventrad when the labrum and labium are extruded. The interrelationship between the mouth-parts and the epipharynx and hypopharynx is fixed and is never changed thruout the order no matter what other specializations may take place. The striking feature concerning the epipharynx and the hypopharynx of various genera having functional mouth-parts is their decided similarity thruout the order and emphasized by the numerous figures. The parts undergo secondary changes in their size and shape, but in no case is there an entire loss of a part which happens with the mouth-appendages. The epipharynx and hypopharynx of the Calyptrata in particular show a development of joints, secondary sclerites, and membranous areas which permit of ^aconsiderable amount of flexibility.

VIII. SUMMARY.

This investigation deals with the homology of all the sclerites of the fixed and movable parts of the head of one or more representatives of fifty-three of the ^{sixty-nine} ~~sixty~~ families of Diptera. With this large series it has been possible to make clear a number of little understood relationships and structural modifications in the head and mouth-parts, and also to point out their homology with the corresponding parts and areas in insects of other orders. The six hundred and more figures show the form and structure of all the parts for each of the families studied.

The modifications in the fixed and movable parts are due principally to reduction, change in form, the loss of chitinization and the increase in the extent of the membranous areas. The different parts have been discussed separately and an hypothetical or typical type formulated for each.

One of the most important interpretations pertaining to the generalized head-capsule is in respect to the location of the epicranial suture. The stem of this suture along the dorso-meson represents the line of fusion of the paired sclerites of the head while the arms of the suture ventrad of the antennal fossae enclose the unpaired sclerites of the head. This suture resembles the epicranial suture in the immature stages and the adult forms of all the generalized members of the more common orders.

Two unpaired sclerites, front and clypeus, are enclosed by the fork of the epicranial suture and ^aare continuous areas in all but one, or two genera, ~~and~~ designated as the fronto-clypeus.

The labrum is an unpaired, distinct, tongue-like structure located ventrad of the fronto-clypeus. It is joined with the epipharynx.

ynx and the ^{resulting} ~~###~~ structure ^{is} ~~is~~ known as the labrum-epipharynx.

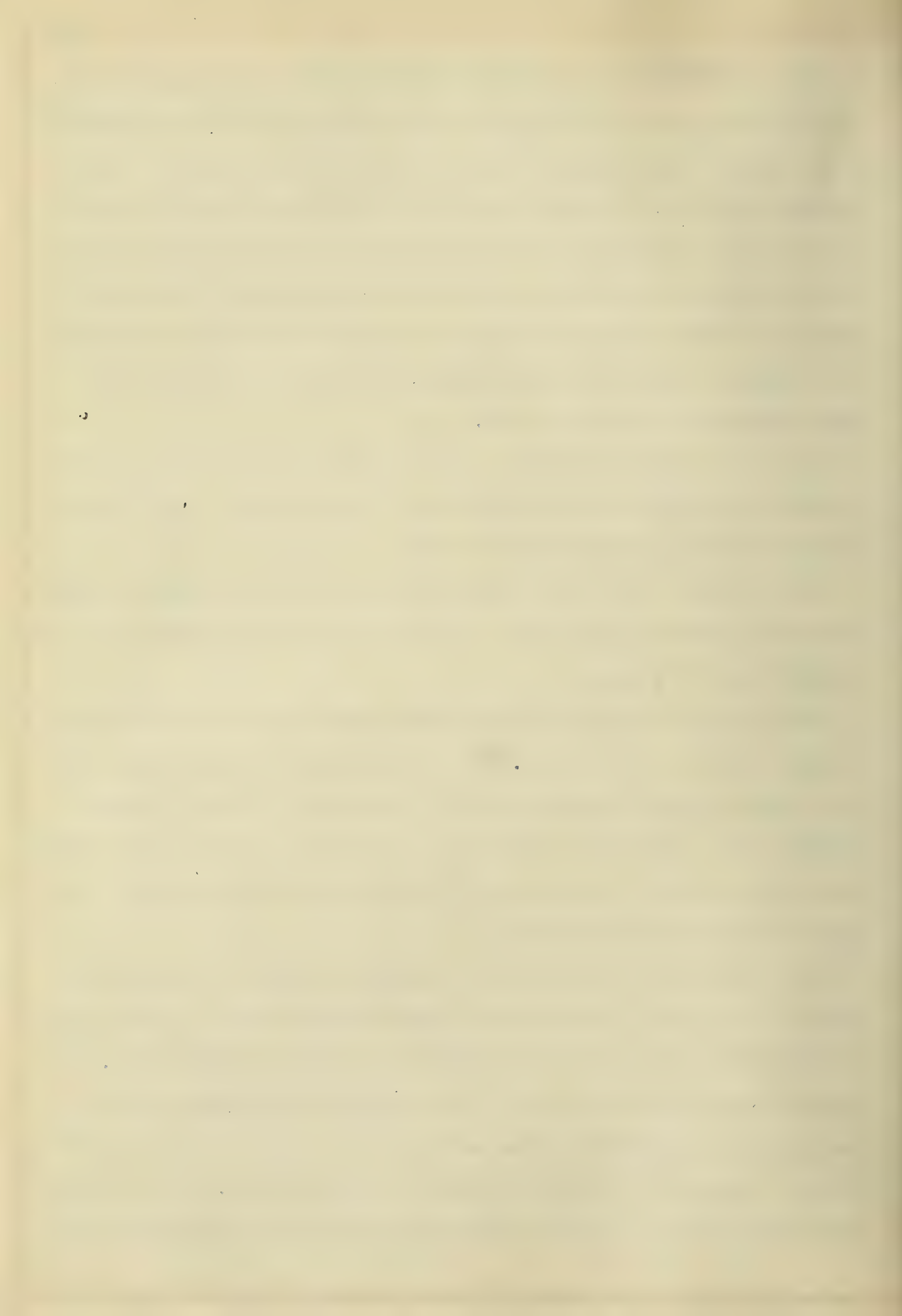
The tormae are the chitinized lateral pieces of the epipharynx which project cephalad and join with the fronto-clypeus in generalized Diptera. They are also present in such generalized insects as the Orthoptera. In the more specialized Diptera the tormae are interpolated between the fronto-clypeus and the labrum and in all but a few genera lose all connection with the chitinized portions of the fronto-clypeus. Their exposed surface is best seen from a cephalic view.

The crescent-shaped frontal suture dorsad of the antennal fossae marks the line of invagination of the ptilinum. The origin of the ptilinum has not been determined.

The vertex is the paired continuous area on the cephalic aspect of the head, and the region of the vertex ventrad and mesad of each compound eye is a gena.

The compound eyes are usually large, and located on the cephalo-lateral aspects of the head. ^{They} ~~They~~ show secondary sexual characters in a greater number of species than any other of the fixed and movable parts. The three ocelli are arranged in the form of a triangle and located on the vertex dorsad of the bifurcation of the arms of the epicranial suture.

The occiput and postgenae are continuous areas on the caudal aspect. The former occupies the dorsal portion and is secondarily modified about the occipital foramen to form the parocciput. The postgenae are the two areas of the ventral half, separated by a membrane in generalized forms and united ventrad of the occipital foramen in all the Brachycera and the Cyclorrhapha. They are also secondarily divide into parapostgenae along the mesal suture.



The tentorium of generalized Diptera is represented by the usual three pairs of arcs and a rudimentary body of the tentorium. It undergoes striking modifications, and influences to a considerable extent the detailed structure of the head. The relationship between the invaginations of the tentorium and the movable appendages of the mouth, which is so important a feature of all generalized insects, is also characteristic of the members of this order.

The development of the antennae from a generalized filiform type to that found among the Cyclorrhapha can be traced *in the figures.*

Only a few generalized Diptera possess mandibles, which are present only in the female, except Simuliid, where they are well developed in both sexes.

All Diptera having functional mouth-parts possess maxillae. The maxillae of generalized Diptera resemble the maxillae of generalized insects except for the absence of palpifers and the fusion of the cardines and stipites with the head-capsule. The maxillae undergo considerable modification and are reduced to a mere ental rod and a palpus in the Calyptratae.

The labium is the most characteristic and specialized appendage of the mouth and shows modifications due to ~~the~~ reduction and membranous development. The palpifers and labial palpi are always wanting. The submentum and mentum are represented by a membranous area of the caudal aspect of the head. The ligula, or the movable portion of the labium, ^{has} ~~possesses~~ a basal part which usually gives rise to two large bulb-like paraglossae and to glossae which are located between them. The paraglossae are specialized and ^{have} ~~possess~~ chitinized areas on their lateral and caudal aspects and pseudo-

tracheae on their mesal aspects.

The parts of the epipharynx and the hypopharynx can be homologized with the corresponding parts in generalized insects. There is a great similarity in the form and shape of the epipharynx and the hypopharynx of all the Diptera which is especially striking when considered in the light of the modifications that have taken place in all other parts.

The various mouth-parts show striking structural modifications thruout the order, but in all cases, including the epipharynx and the hypopharynx, they retain their relative position even tho they may be extruded from the head-capsule for a considerable distance, as in some of the Calyptratae. The proboscis of the Cyclorhaga is composed of the labium, maxillae, hypopharynx, labrum-epipharynx and t. r. The paraglossae of the labium form the large lobes or labellae at its distal end.

The mouth-parts of Oncodes and Gastrophilus are not functional, and are so greatly reduced that it is difficult to homologize their parts.

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1915. Publication, "Morphological Studies on the Head and Mouth-parts of the Thysanoptera."
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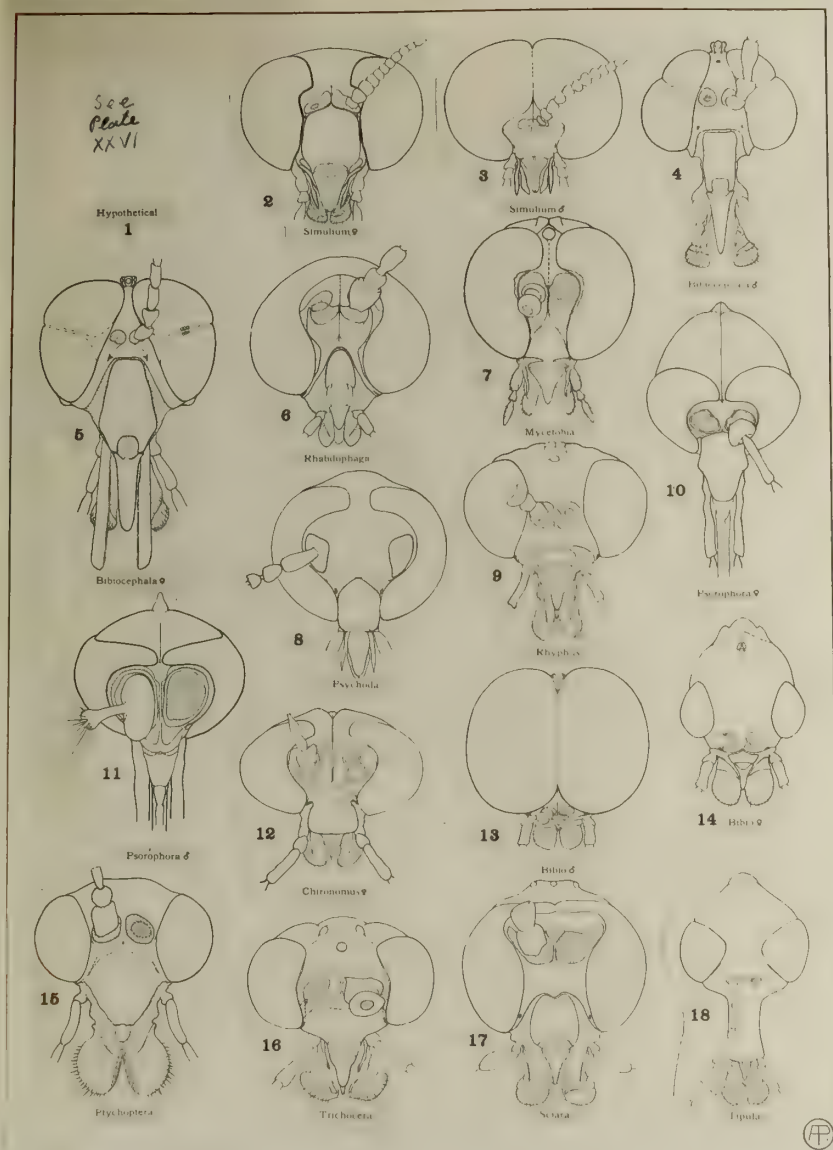
A member of the Entomological Society of America, American Association of Economic Entomologists, Gamma Alpha, and Sigma Xi.

EXPLANATION OF PLATE I.

Cephalic Aspect of the Head.

- Fig. 1. Hypothetical Head.
- Fig. 2. *Simulium venustum*, female.
- Fig. 3. *Simulium Johannseni*, male.
- Fig. 4. *Bibliocephala elegantula*, male.
- Fig. 5. *Bibliocephala elegantula*, female.
- Fig. 6. *Rhabdophaga strobiloides*.
- Fig. 7. *Mycetobia divergens*.
- Fig. 8. *Psychoda albipennis*.
- Fig. 9. *Rhyphus punctatus*.
- Fig. 10. *Psorophora ciliata*, female.
- Fig. 11. *Psorophora ciliata*, male.
- Fig. 12. *Chironomus ferrugineovittatus*, female.
- Fig. 13. *Bibio femoratus*, male.
- Fig. 14. *Bibio femoratus*, female.
- Fig. 15. *Ptychoptera rufocincta*.
- Fig. 16. *Trichocera bimacula*.
- Fig. 17. *Sciara varians*.
- Fig. 18. *Tipula bicornis*.

PLATE I.

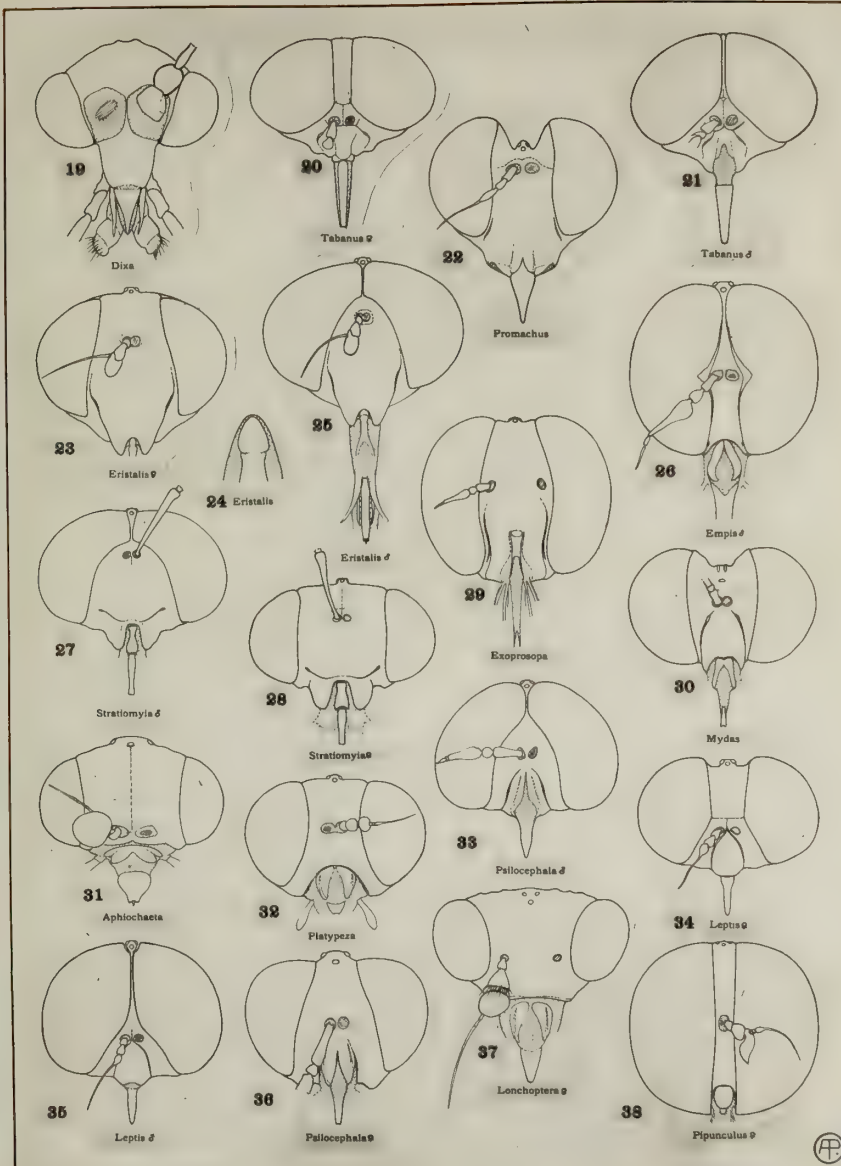


EXPLANATION OF PLATE II.

Cephalic Aspect of the Head.

- Fig. 19. *Dixa clavata*.
Fig. 20. *Tabanus giganteus*, female.
Fig. 21. *Tabanus giganteus*, male.
Fig. 22. *Promachus vertebratus*.
Fig. 23. *Eristalis tenax*, female.
Fig. 24. *Eristalis tenax*, dorsal end of clypeus.
Fig. 25. *Eristalis tenax*, male.
Fig. 26. *Empis clausa*, male.
Fig. 27. *Stratiomyia apicula*, male.
Fig. 28. *Stratiomyia apicula*, female.
Fig. 29. *Exoprosopa fasciata*.
Fig. 30. *Mydas clavatus*.
Fig. 31. *Aphiochaeta agarici*.
Fig. 32. *Platypeza velutina*.
Fig. 33. *Psilocephala haemorrhoidalis*, male.
Fig. 34. *Leptis vertebrata*, female.
Fig. 35. *Leptis vertebrata*, male.
Fig. 36. *Psilocephala haemorrhoidalis*, female.
Fig. 37. *Lonchoptera lutea*, female.
Fig. 38. *Pipunculus cingulatus*, female.

PLATE II.

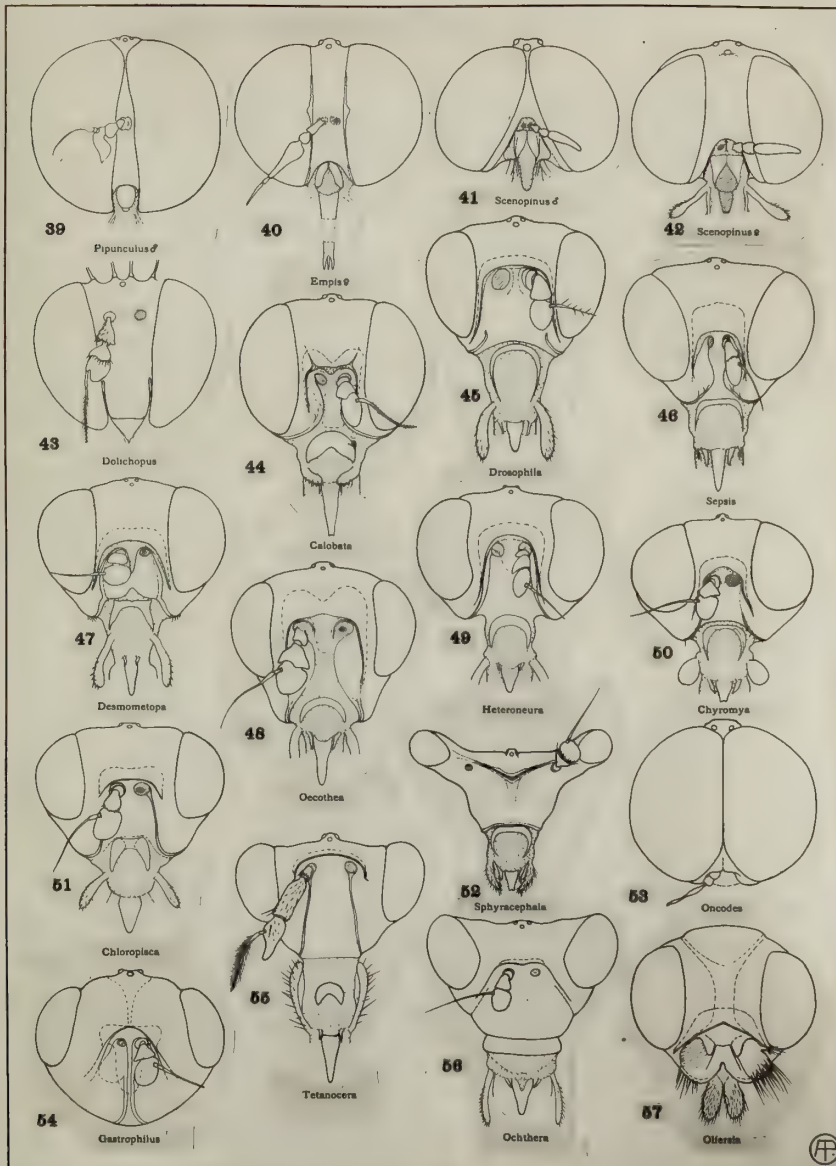


EXPLANATION OF PLATE III.

Cephalic Aspect of the Head.

- Fig. 39. *Pipunculus cingulatus*, male.
Fig. 40. *Empis clausa*, female.
Fig. 41. *Scenopinus fenestralis*, male.
Fig. 42. *Scenopinus fenestralis*, female.
Fig. 43. *Dolichopus bifractus*.
Fig. 44. *Calobata univitta*.
Fig. 45. *Drosophila* ^P~~amel~~elophila.
Fig. 46. *Sepsis violacea*.
Fig. 47. *Desmometopa latipes*.
Fig. 48. *Oecothoa fenestralis*.
Fig. 49. *Heteroneura flavifacies*.
Fig. 50. *Chyromya concolor*.
Fig. 51. *Chloropisca glabra*.
Fig. 52. *Sphyracephala brevicornis*.
Fig. 53. *Oncodes costatus*.
Fig. 54. *Castrophilus equi*.
Fig. 55. *Tetanocera plumosa*.
Fig. 56. *Ochthera mantis*.
Fig. 57. *Olfersia ardeae*.

PLATE III.

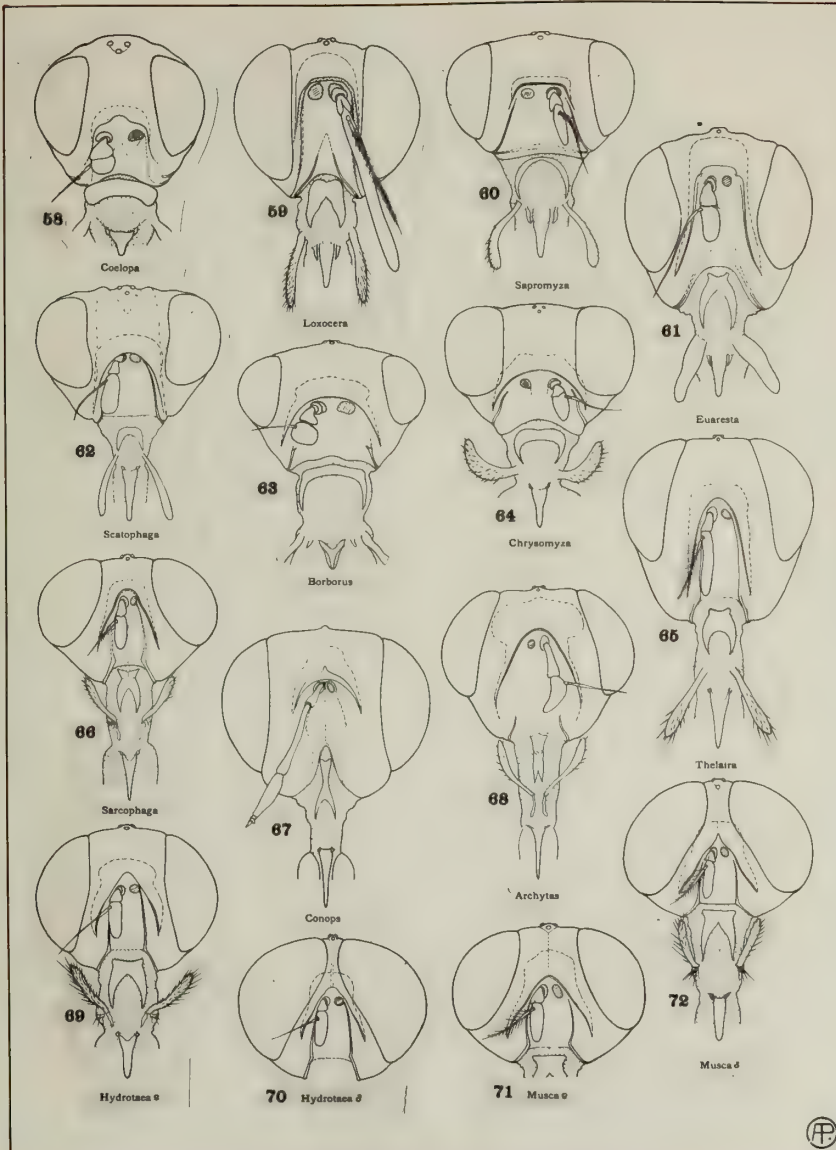


EXPLANATION OF PLATE IV.

Cephalic Aspect of the Head.

- Fig. 58. *Coelopa vanduzeei*.
- Fig. 59. *Loxocera pectoralis*.
- Fig. 60. *Sapromyza vulgaris*.
- Fig. 61. *Euaresta aequalis*.
- Fig. 62. *Scatophaga furcata*.
- Fig. 63. *Borborus equinus*.
- Fig. 64. *Chrysomya demandata*.
- Fig. 65. *Thelaira leucozona*.
- Fig. 66. *Sarcophaga haemorrhoidalis*.
- Fig. 67. *Conops brachyrhynchus*.
- Fig. 68. *Archytas analis*.
- Fig. 69. *Hydrotaea dentipes*, female.
- Fig. 70. *Hydrotaea dentipes*, male.
- Fig. 71. *Musca domestica*, female.
- Fig. 72. *Musca domestica*, male.

PLATE IV.

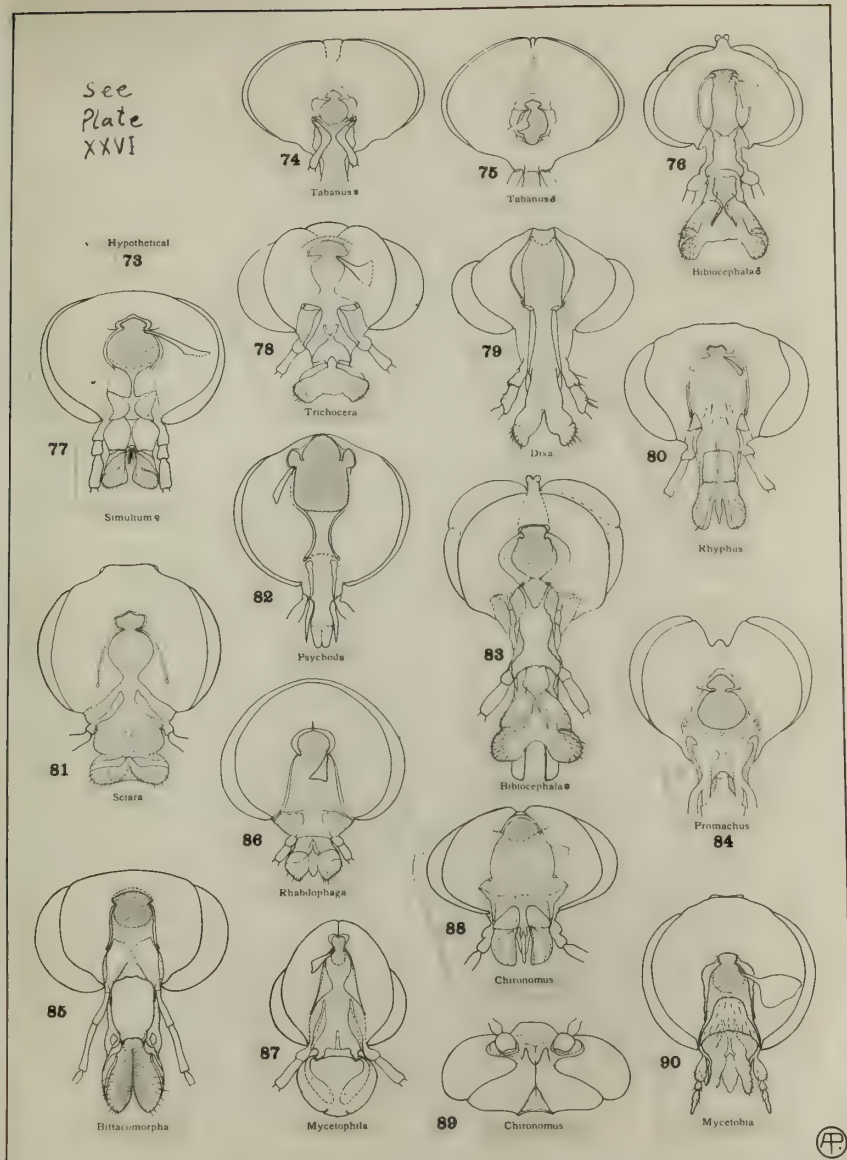


EXPLANATION OF PLATE V.

Caudal Aspect of the Head.

- Fig. 73. Hypothetical Head.
- Fig. 74. *Tabanus giganteus*, female.
- Fig. 75. *Tabanus giganteus*, male.
- Fig. 76. *Bibliocephala elegantula*, male.
- Fig. 77. *Simulium venustum*, female.
- Fig. 78. *Trichocera bimacula*.
- Fig. 79. *Dixa clavata*.
- Fig. 80. *Rhyphus punctatus*.
- Fig. 81. *Sciara varians*.
- Fig. 82. *Psychoda albipennis*.
- Fig. 83. *Bibliocephala elegantula*, female.
- Fig. 84. *Promachus vertebratus*.
- Fig. 85. *Bittacomorpha clavipes*.
- Fig. 86.. *Rhabdophaga strobiloides*.
- Fig. 87. *Mycetophila punctata*.
- Fig. 88. *Chironomus ferrugineovittatus*.
- Fig. 89. *Chironomus ferrugineovittatus*,
dorsal aspect of the head.
- Fig. 90. *Mycetobia divergens*.

PLATE V.

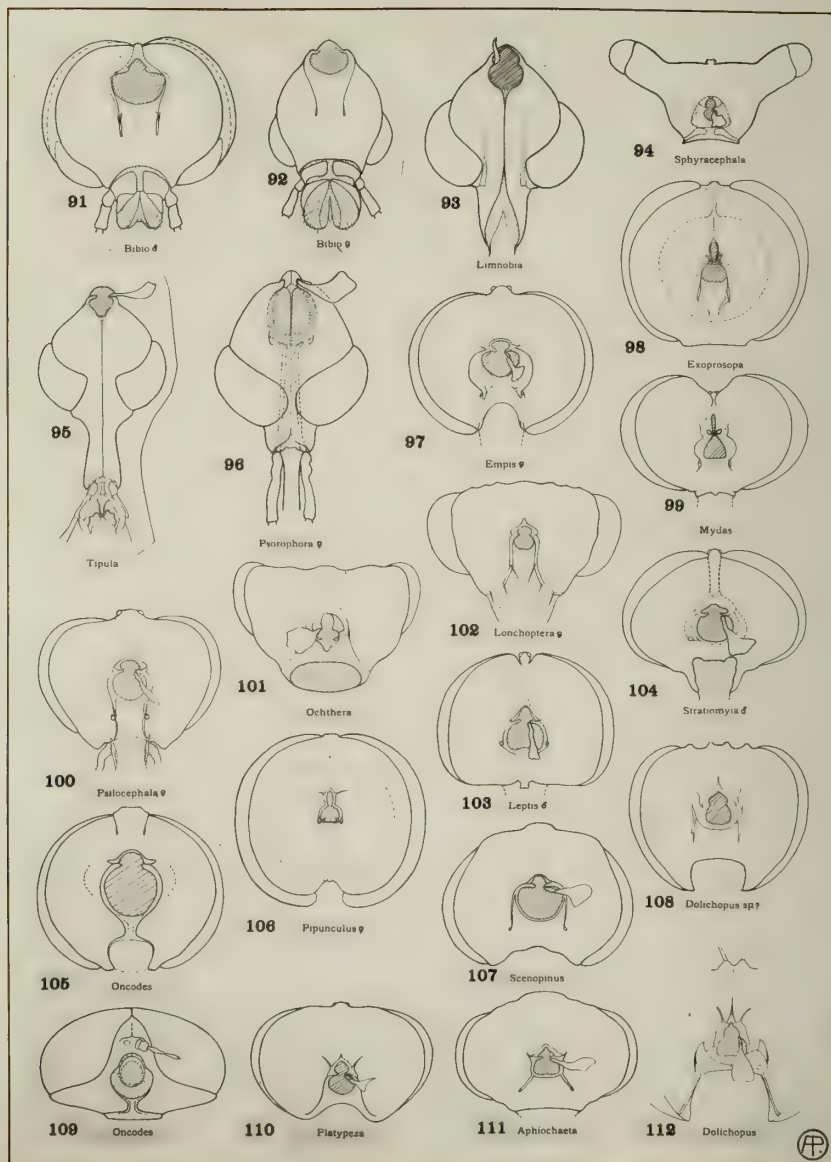


EXPLANATION OF PLATE VI.

Caudal Aspect of the Head.

- Fig. 91. *Bibio femoratus*, male?
Fig. 92. *Bibio femoratus*, female.
Fig. 93. *Limnobia immatura*.
Fig. 94. *Sphyracephala brevicornis*.
Fig. 95. *Tipula bicornis*.
Fig. 96. *Psorophora ciliata*, female.
Fig. 97. *Empis clausa*, female.
Fig. 98. *Exoprosopa fasciata*.
Fig. 99. *Mydas clavatus*.
Fig. 100. *Psilocephala haemorrhoidalis*, female.
Fig. 101. *Ochthera mantis*.
Fig. 102. *Lonchoptera lutea*, female.
Fig. 103. *Leptis vertebrata*, male.
Fig. 104. *Stratiomyia apicula*, male.
Fig. 105. *Oncodes costatus*.
Fig. 106. *Pipunculus cingulatus*, female.
Fig. 107. *Scenopinus fenestralis*.
Fig. 108. *Dolichopus* sp?
Fig. 109. *Oncodes costatus*, ventral aspect.
Fig. 110. *Platypeza velutina*.
Fig. 111. *Aphiochaeta agarici*.
Fig. 112. *Dolichopus bifractus*, lateral
margins incomplete.

PLATE VI.

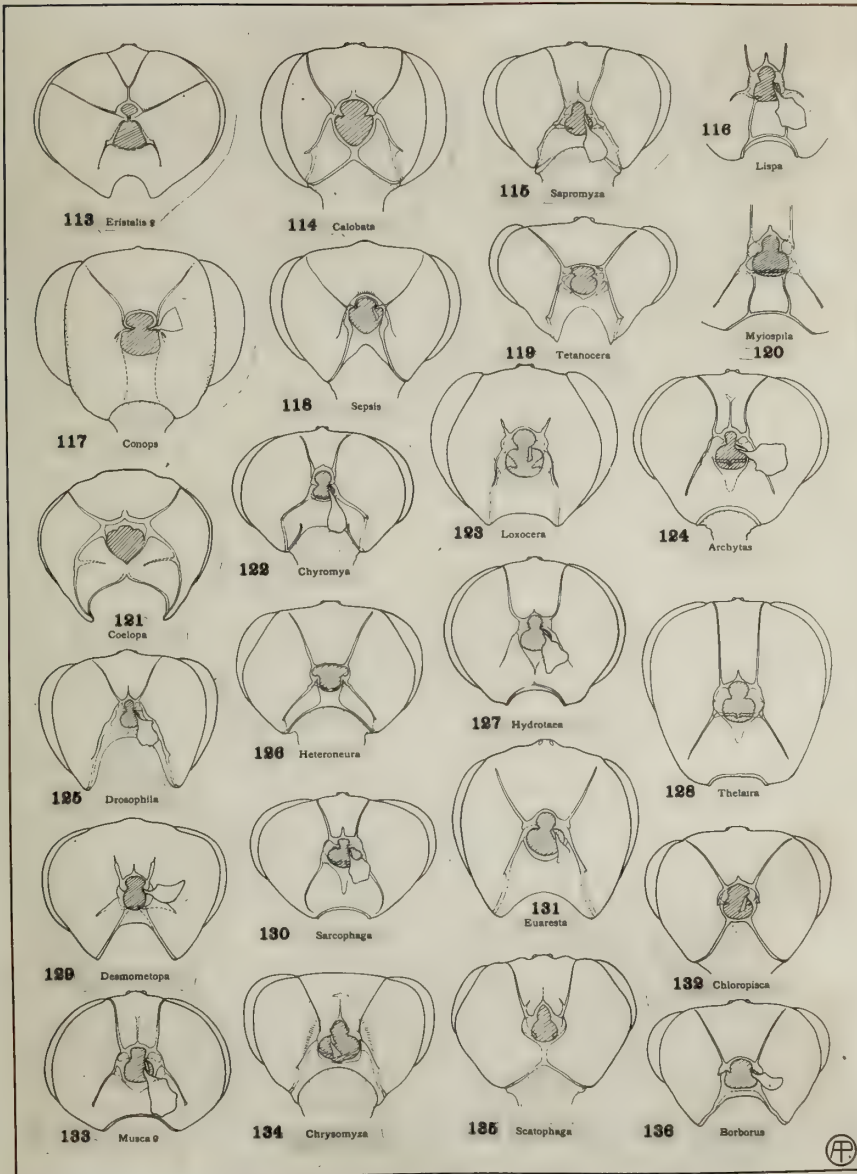


EXPLANATION OF PLATE VII.

Caudal Aspect of the Head.

- Fig. 113. *Eristalis tenax*, female.
Fig. 114. *Calobata univitta*.
Fig. 115. *Sapromyza vulgaris*.
Fig. 116. *Lispa nasoni*, margin incomplete.
Fig. 117. *Conops brachyrhynchus*.
Fig. 118. *Sepsis violacea*.
Fig. 119. *Tetanocera plumosa*.
Fig. 120. *Myiospila meditabunda*,
margin incomplete.
Fig. 121. *Coelopa vanduzeei*.
Fig. 122. *Chyromya concolor*.
Fig. 123. *Loxocera pectoralis*.
Fig. 124. *Archytas analis*.
Fig. 125. *Drosophila* ^P*amelophila*.
Fig. 126. *Heteroneura flavifacies*.
Fig. 127. *Hydrotaea dentipes*.
Fig. 128. *Thelaira leucozona*.
Fig. 129. *Desmometopa latipes*.
Fig. 130. *Sarcophaga haemorrhoidalis*.
Fig. 131. *Euaresta aequalis*.
Fig. 132. *Chloropisca glabra*.
Fig. 133. *Musca domestica*, female.
Fig. 134. *Chrysomya demandata*.
Fig. 135. *Scatophaga furcata*.
Fig. 136. *Borborus equinus*.

PLATE VII.

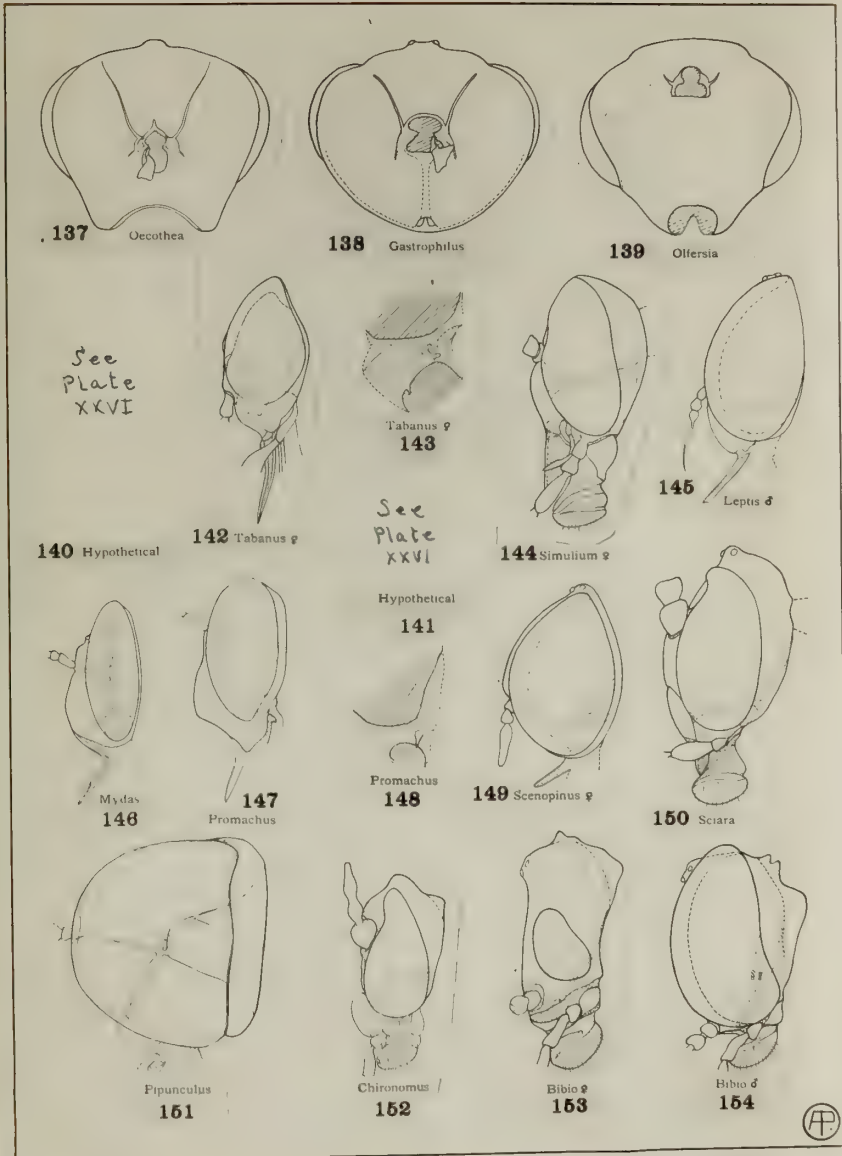


EXPLANATION OF PLATE VIII.

Caudal and Lateral Aspects of the Head and the Tentorium.

- Fig. 137. *Oecothoa fenestralis*, caudal aspect.
- Fig. 138. *Gastrophilus equi*, caudal aspect.
- Fig. 139. *Olfersia ardeae*, caudal aspect.
- Fig. 140. Hypothetical Type, lateral aspect.
- Fig. 141. Hypothetical Type, lateral aspect of the tentorium
- Fig. 142. *Tabanus giganteus*^e, female, lateral aspect.
- Fig. 143. *Tabanus giganteus*^e, lateral aspect of the tentorium.
- Fig. 144. *Simulium venustum*, female, lateral aspect.
- Fig. 145. *Leptis vertebrata*, male, lateral aspect.
- Fig. 146. *Mydas clavatus*, lateral aspect.
- Fig. 147. *Promachus vertebratus*, lateral aspect.
- Fig. 148. *Promachus vertebratus*, lateral aspect of the tentorium
- Fig. 149. *Scenopinus fenestralis*, female, lateral aspect.
- Fig. 150. *Sciara varians*, lateral aspect.
- Fig. 151. *Pipunculus cingulatus*, lateral aspect.
- Fig. 152. *Chironomus ferrugineovittatus*, lateral aspect.
- Fig. 153. *Bibio femoratus*, female, lateral aspect.
- Fig. 154. *Bibio femoratus*, male, lateral aspect.

PLATE VIII.

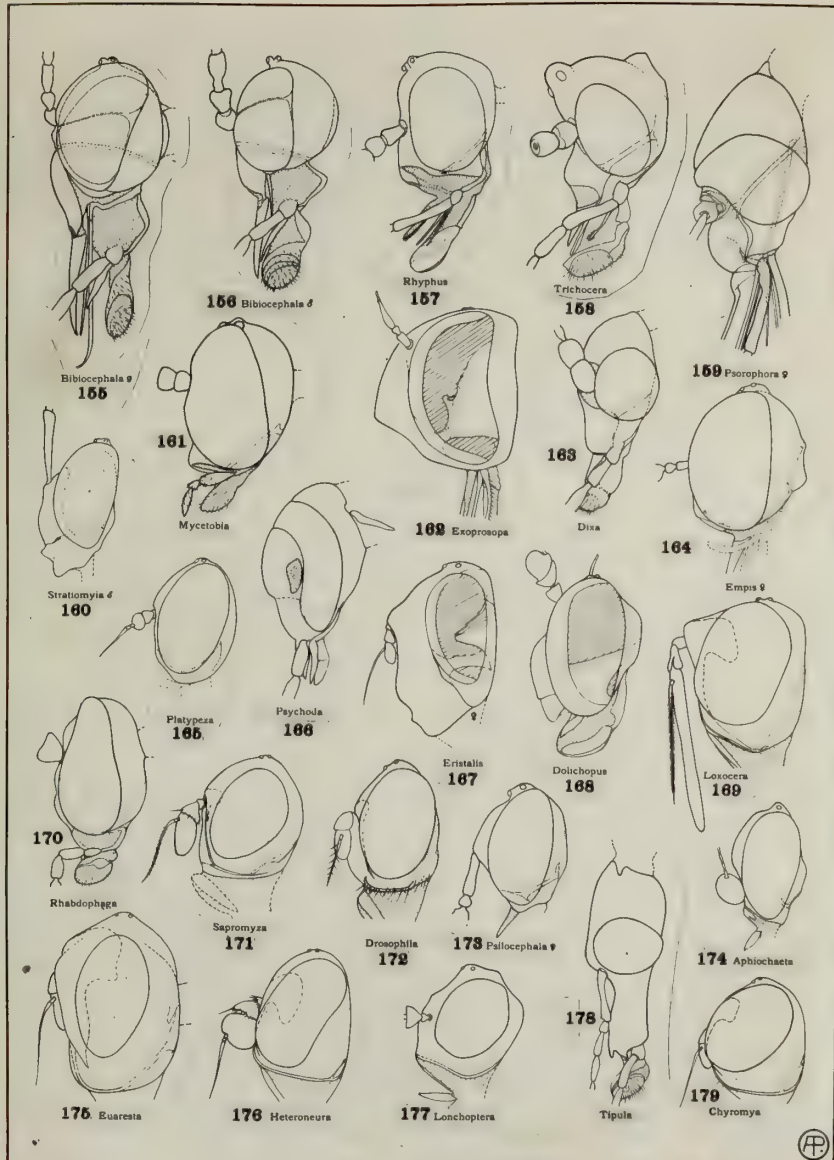


EXPLANATION OF PLATE IX.

Lateral Aspect of the Head showing the Tentorium.

- Fig. 155. *Bibiocephala elegantula*, female.
Fig. 156. *Bibiocephala elegantula*, male.
Fig. 157. *Rhyphus punctatus*.
Fig. 158. *Trichocera bimacula*.
Fig. 159. *Psorophora ciliata*, female.
Fig. 160. *Stratiomyia apicula*, male.
Fig. 161. *Mycetobia divergens*.
Fig. 162. *Exoprosopa fasciata*, eye removed.
Fig. 163. *Dixa clavata*.
Fig. 164. *Empis clausa*, female.
Fig. 165. *Platypeza velutina*.
Fig. 166. *Psychoda albipennis*.
Fig. 167. *Eristalis tenax*, female, eye removed.
Fig. 168. *Dolichopus bifractus*, eye removed.
Fig. 169. *Loxocera pectoralis*.
Fig. 170. *Rhabdophaga strobiloides*.
Fig. 171. *Sapromyza vulgaris*.
Fig. 172. *Drosophila amelophila*.
Fig. 173. *Psilocephala haemorrhoidalis*, female.
Fig. 174. *Aphiochaeta agarici*.
Fig. 175. *Euaresta aequalis*.
Fig. 176. *Heteroneura flavifacies*.
Fig. 177. *Lonchoptera lutea*.
Fig. 178. *Tipula bicornis*.
Fig. 179. *Chyromya concolor*.

PLATE IX.



EXPLANATION OF PLATE X.

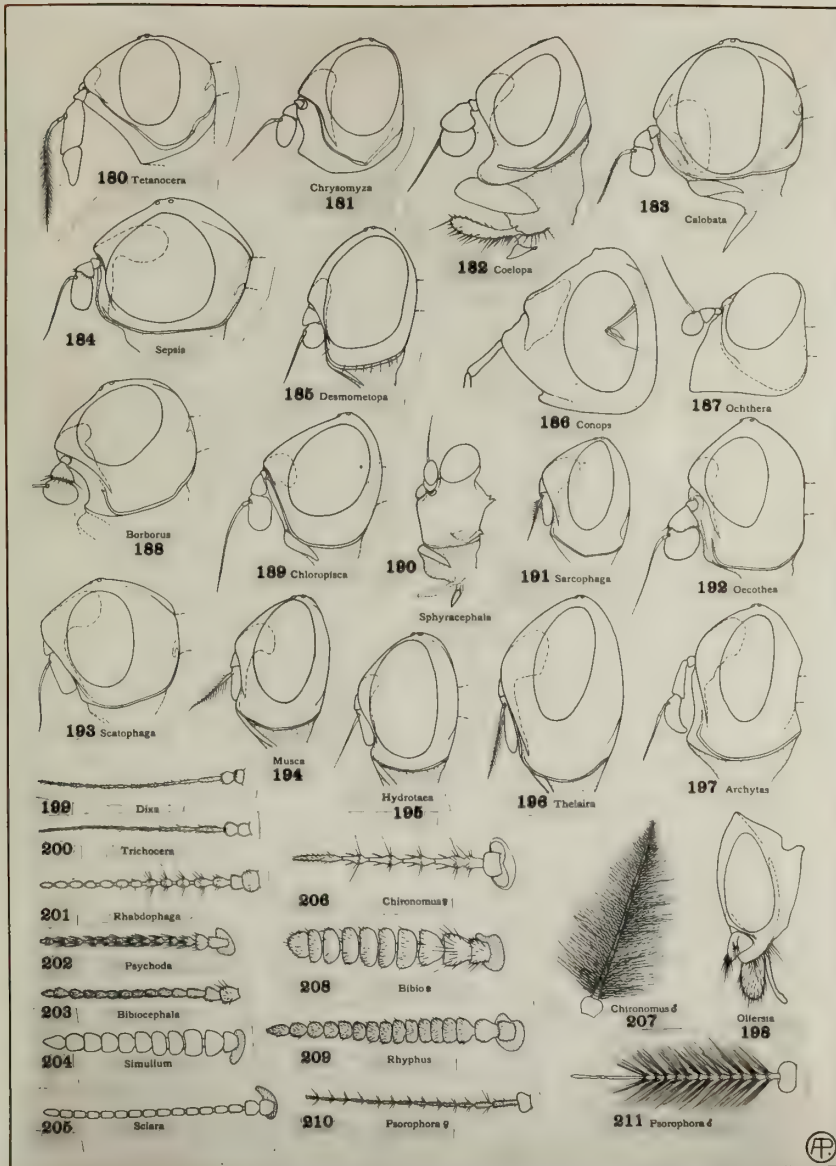
Lateral Aspect of the Head.

- Fig. 180. *Tetanocera plumosa*.
- Fig. 181. *Chrysomya demandata*.
- Fig. 182. *Coelopa vanduzeei*.
- Fig. 183. *Calobata unhivitta*.
- Fig. 184. *Sepsis violacea*.
- Fig. 185. *Desmometopa latipes*.
- Fig. 186. *Conops brachyrhynchus*.
- Fig. 187. *Ochthera mantis*.
- Fig. 188. *Borborus equinus*.
- Fig. 189. *Chloropisca*.
- Fig. 190. *Sphyracephala brevicornis*.
- Fig. 191. *Sarcophaga haemorrhoidalis*.
- Fig. 192. *Oeciothea fenestralis*.
- Fig. 193. *Scatophaga furcata*.
- Fig. 194. *Musca domestica*.
- Fig. 195. *Hydrotaea*⁹⁹⁹~~111~~ *dentipes*.
- Fig. 196. *Thelaira leucozona*.
- Fig. 197. *Archytas analis*.
- Fig. 198. *Olfersia ardeae*.

Antennae.

- Fig. 200. *Dixa clavata*.
- Fig. 201. *Trichocera bimacula*.
- Fig. 202. *Rhabdophaga strobiloides*.
- Fig. 203. *Psychoda albipennis*.
- Fig. 204. *Bibliocephala elegantula*.
- Fig. 205. *Simulium venustum*.
- Fig. 206. *Sciara varians*.
- Fig. 207. *Chironomus ferrugineovittatus*, female.
- Fig. 208. *Chironomus ferrugineovittatus*, male.
- Fig. 209. *Bibio femoratus*, female.
- Fig. 210. *Thyphus punctatus*.
- Fig. 211. *Psorophora ciliata*, female.
- Fig. 212. *Psorophora ciliata*, male.

PLATE X.



EXPLANATION OF PLATE XI.

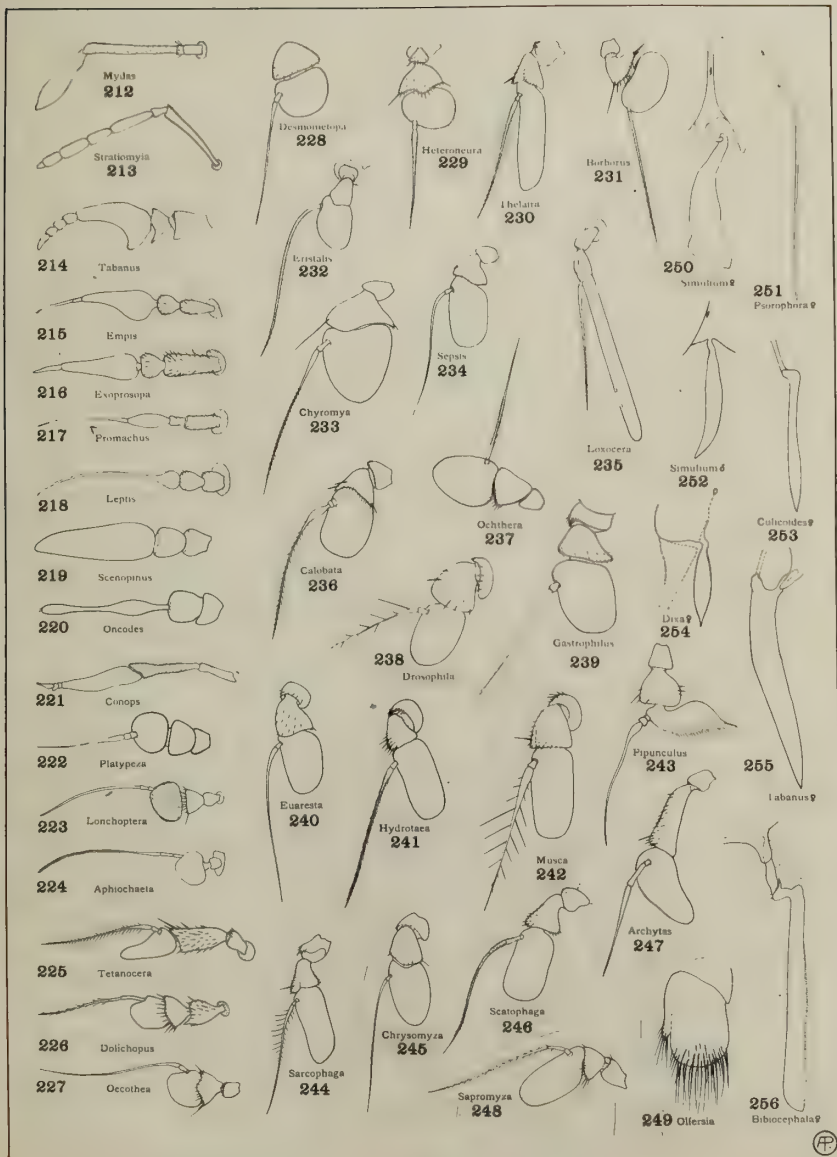
Antennae.

- FIG. 212. *Mydas clavatus*.
FIG. 213. *Stratiomyia apicula*.
FIG. 214. *Tabanus giganteus*.
FIG. 215. *Empis clausa*.
FIG. 216. *Exoprosopa*.
FIG. 217. *Promachus vertebratus*.
FIG. 218. *Leptis vertebrata*.
FIG. 219. *Scenopinus fenestralis*.
FIG. 220. *Oncodes costatus*.
FIG. 221. *Conops brachyrhynchus*.
FIG. 222. *Platypeza velutina*.
FIG. 223. *Lonchoptera lutea*.
FIG. 224. *Aphiochaeta agarici*.
FIG. 225. *Tetanocera plumosa*.
FIG. 226. *Dolichopus bifractus*.
FIG. 227. *Oeciothea fenestralis*.
FIG. 228. *Desmometopa latipes*.
FIG. 229. *Heteroneura flavifacies*.
FIG. 230. *Thelaira leucozona*.
FIG. 231. *Borborus equinus*.
FIG. 232. *Eristalis tenax*.
FIG. 233. *Chrysomya concolor*.
FIG. 234. *Sepsis violacea*.
FIG. 235. *Loxocera pectoralis*.
FIG. 236. *Calobata univitta*.
FIG. 237. *Ochthera mantis*.
FIG. 238. *Drosophila amelophila*.
FIG. 239. *Gastrophilus equi*.
FIG. 240. *Euaresta aequalis*.
FIG. 241. *Hydrotaea dentipes*.
FIG. 242. *Musca domestica*.
FIG. 243. *Pipunculus cingulatus*.
FIG. 244. *Sarcophaga haemorrhoidalis*.
FIG. 245. *Chrysomya demandata*.
FIG. 246. *Scatophaga furcata*.
FIG. 247. *Archytas analis*.
FIG. 248. *Sapromyza vulgaris*.
FIG. 249. *Olfersia ardeae*.

Mandibles.

- FIG. 250. *Simulium venustum*, female.
FIG. 251. *Psorophora ciliata*, female.
FIG. 252. *Simulium johannseni*, male.
FIG. 253. *Culicoides sanguisugus*, female.
FIG. 254. *Dixa modesta*, female.
FIG. 255. *Tabanus giganteus*, female.
FIG. 256. *Bibliocephala elegantula*, female.

PLATE XI.



EXPLANATION OF PLATE XII.

Maxillae.

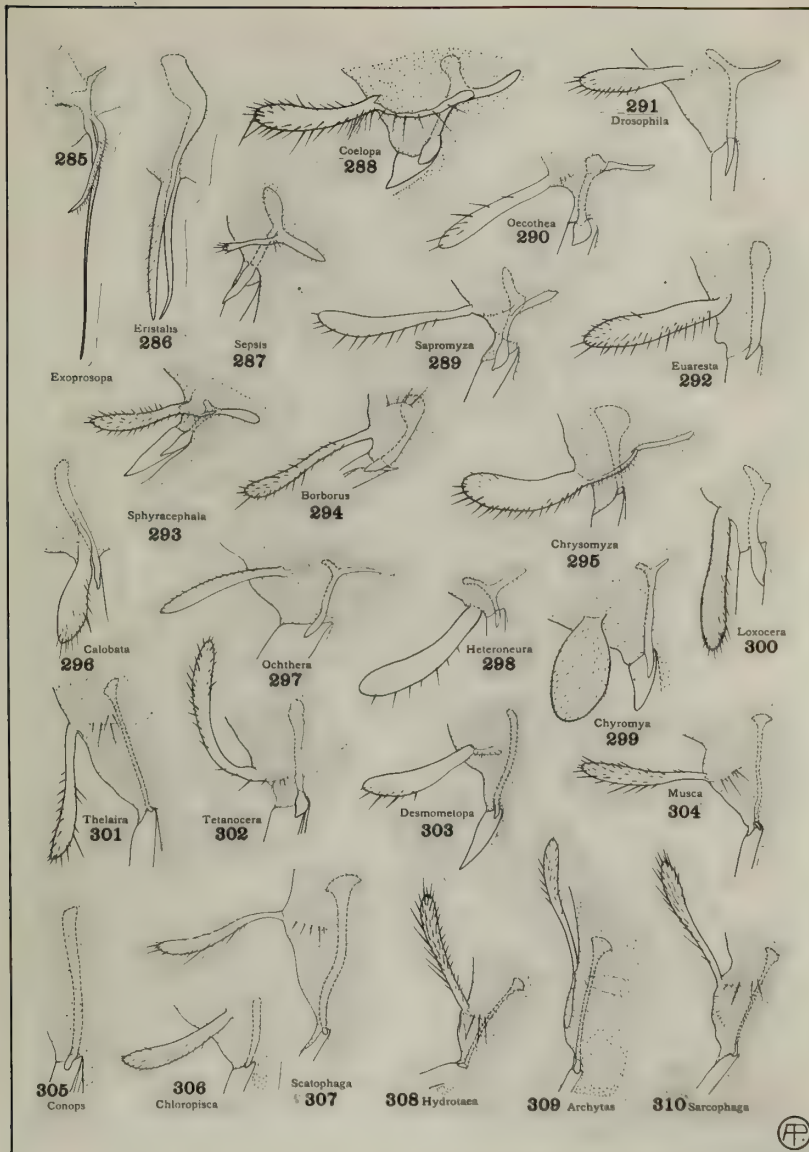
- Fig. 257. Hypothetical Type.
- Fig. 258. *Simulium venustum*, female, cephalic aspect.
- Fig. 259. *Tabanus gigantius*, female, caudal aspect.
- Fig. 260. *Trichocera bimacula*, caudal aspect.
- Fig. 261. *Rhyphus punctatus*, caudal aspect.
- Fig. 262. *Dixa clavata*, caudal aspect.
- Fig. 263. *Psychoda albipennis*, caudal aspect.
- Fig. 265. *Culicoides sanguisugus*, female, caudal aspect.
- Fig. 264. *Bibio femoratus*, caudal aspect.
- Fig. 266. *Psorophora ciliata*, female and male, caudal.
- Fig. 267. *Sciara varians*, caudal aspect.
- Fig. 268. *Rhabdophaga strobiloides*, caudal aspect.
- Fig. 269. *Bibliocephala elegantula*, female, caudal aspect.
- Fig. 270. *Chironomus ferrugineovittatus*, cephalic aspect.
- Fig. 271. *Mydas clavatus*, lateral aspect.
- Fig. 272. *Platypeza velutina*, lateral aspect.
- Fig. 273. *Stratiomyia apicula*, cephalic aspect.
- Fig. 274. *Empis clausa*, lateral aspect.
- Fig. 275. *Leptis vertebrata*, caudal aspect.
- Fig. 276. *Promachus vertebratus*, caudal aspect.
- Fig. 277. *Tipula bicornis*, portion of caudal aspect.
- Fig. 278. *Aphiochaeta agarici*, lateral aspect.
- Fig. 279. *Pipunculus cingulatus*, lateral aspect.
- Fig. 281. *Psilocephala haemorhoidalis*, cephalic aspect.
- Fig. 280. *Lonchoptera lutea*.
- Fig. 282. *Scenopinus fenestralis*.
- Fig. 283. *Tabanus gigantius*, male, caudal aspect.
- Fig. 284. *Dolichopus bifractus*.

EXPLANATION OF PLATE XIII.

Maxillae.

- Fig. 285. *Exoprosopa fasciata*.
- Fig. 286. *Eristalis tenax*.
- Fig. 287. *Sepsis violacea*.
- Fig. 288. *Coelopa vanduzeei*.
- Fig. 289. *Sapromyza vulgaris*.
- Fig. 290. *Oecothoa fenestralis*.
- Fig. 291. *Drosophila* ^P~~am~~^K*elophila*.
- Fig. 292. *Euaresta aequalis*.
- Fig. 293. *Sphyracephala brevicornis*.
- Fig. 294. *Borborus equinus*.
- Fig. 295. *Chrysomya demandata*.
- Fig. 296. *Calobata univitta*.
- Fig. 297. *Ochthera mantis*.
- Fig. 298. *Heteroneura flavifacies*.
- Fig. 299. *Chyromya concolor*.
- Fig. 300. *Loxocera pectoralis*.
- Fig. 301. *Thelaira leucozona*.
- Fig. 302. *Tetanocera plumosa*.
- Fig. 303. *Desmometopa latipes*.
- Fig. 304. *Musca domestica*.
- Fig. 305. *Conops brachyrhynchus*.
- Fig. 306. *Chloropisca glabra*.
- Fig. 307. *Scatophaga furcata*.
- Fig. 308. *Hydrotaea dentipes*.
- Fig. 309. *Archytas analis*.
- Fig. 310. *Sarcophaga haemorrhoidalis*.

PLATE XIII.



EXPLANATION OF PLATE XIV.

Lateral Aspect of the Mouth-parts.

Fig. 311. *Trichocera bimacula*.

Fig. 312. *Chironomus ferrugineovittatus*.

Fig. 313. *Rhabdophaga strobiloides*.

Fig. 314. *Sciara varians*.

Fig. 315. *Bibio femoratus*.

Fig. 316. *Simulium venustum*, female.

Fig. 317. *Tabanus giganteus*, female.

Fig. 318. *Psychoda albipennis*.

Fig. 319. *Mydas clavatus*.

Fig. 320. *Lonchoptera lutea*.

Fig. 321. *Rhyphus punctatus*.

Fig. 322. *Promachus vertebratus*.

Fig. 323. *Leptis vertebrata*.

Fig. 324. *Psilocephala haemorrhoidalis*.

Fig. 325. *Scenopinus fenestralis*.

Fig. 326. *Platypeza velutina*.

Fig. 327. *Pipunculus cingulatus*.

Fig. 328. *Eristalis tenax*.

Fig. 329. *Sapromyza vulgaris*.

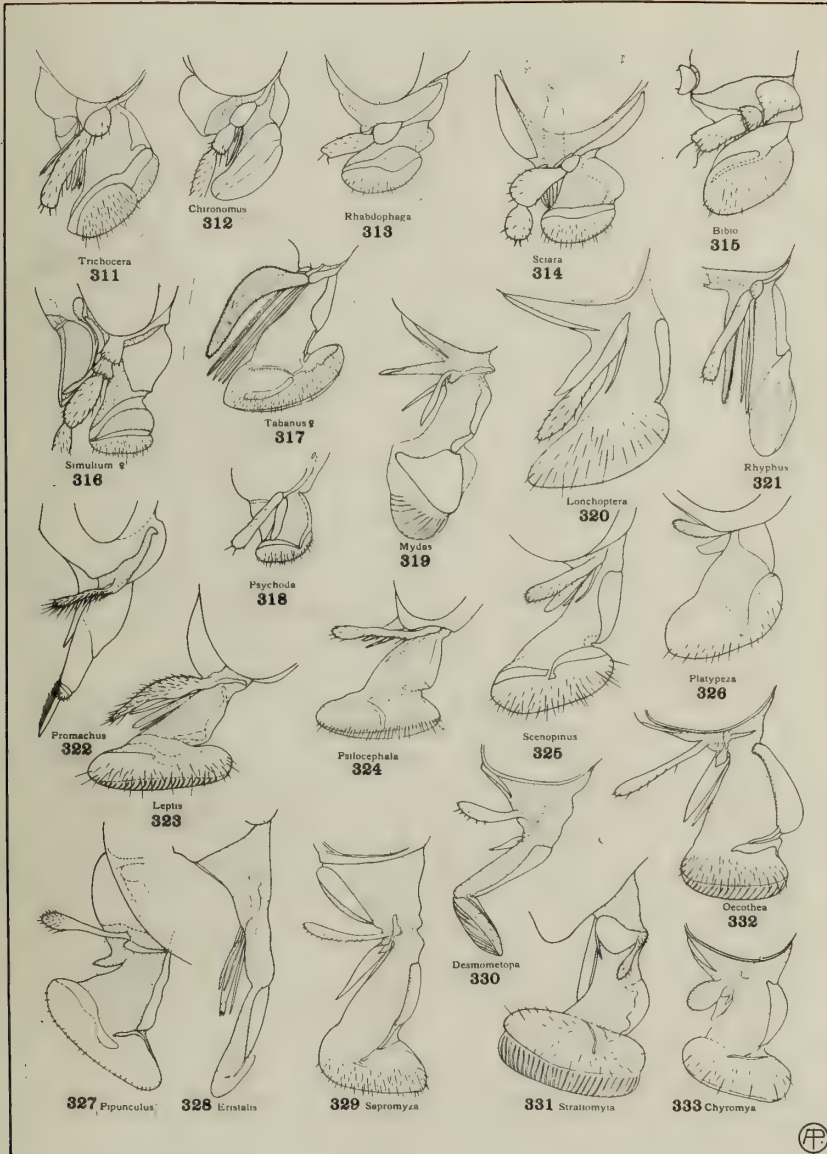
Fig. 330. *Desmometopa latipes*.

Fig. 331. *Stratiomyia apicula*.

Fig. 332. *Oecothoa fenestralis*.

Fig. 333. *Chyromya concolor*.

PLATE XIV.

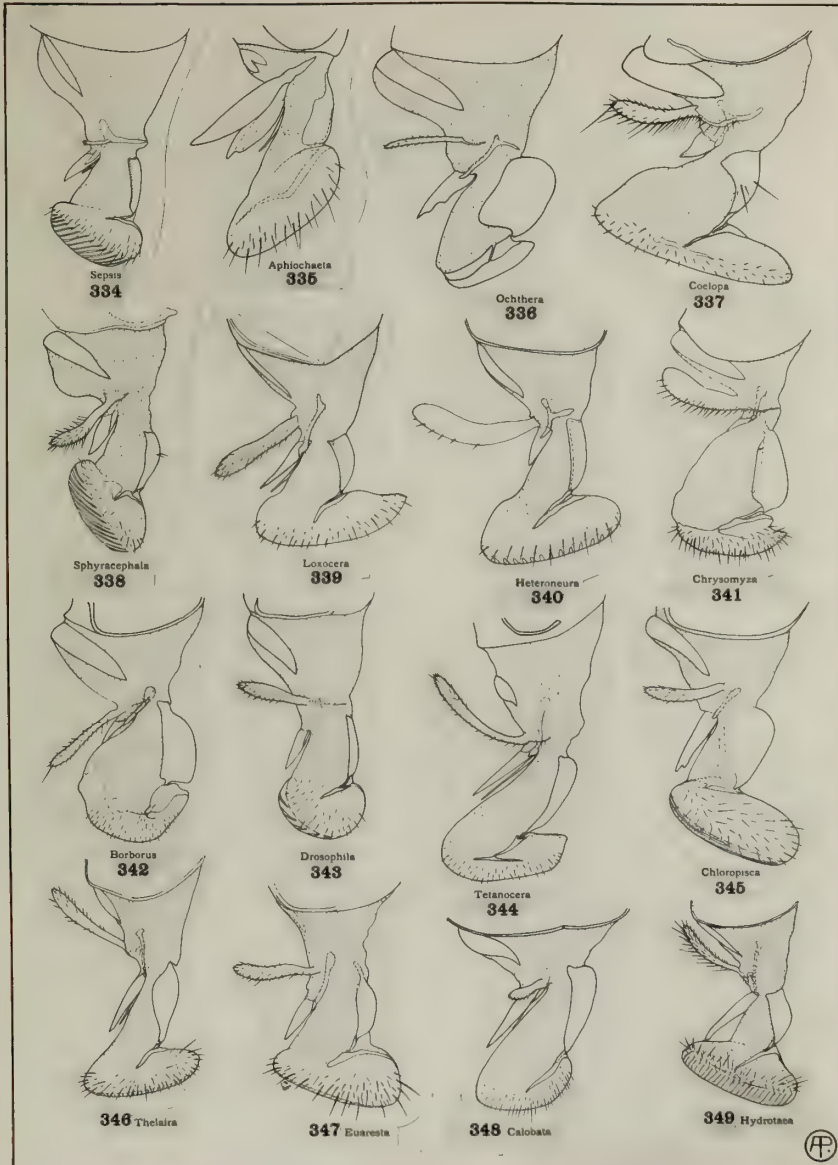


EXPLANATION OF PLATE XV.

Lateral Aspect of the Mouth-parts.

- Fig. 334. *Sepsis violacea*.
Fig. 335. *Aphiochaeta agarici*.
Fig. 336. *Ochthera mantis*.
Fig. 337. *Coelopa vanduzeei*.
Fig. 338. *Sphyracephala brevicornis*.
Fig. 339. *Loxocera pectoralis*.
Fig. 340. *Heteroneura flavifacies*.
Fig. 341. *Chrysomya demandata*.
Fig. 342. *Borborus equinus*.
Fig. 343. *Drosophila* ^p*amelophila*.
Fig. 344. *Tetanocera plumosa*.
Fig. 345. *Chloropisca glabra*.
Fig. 346. *Thelaira leucozona*.
Fig. 347. *Euaresta aequalis*.
Fig. 348. *Calobata univitta*.
Fig. 349. *Hydrotaea dentipes*.

PLATE XV.

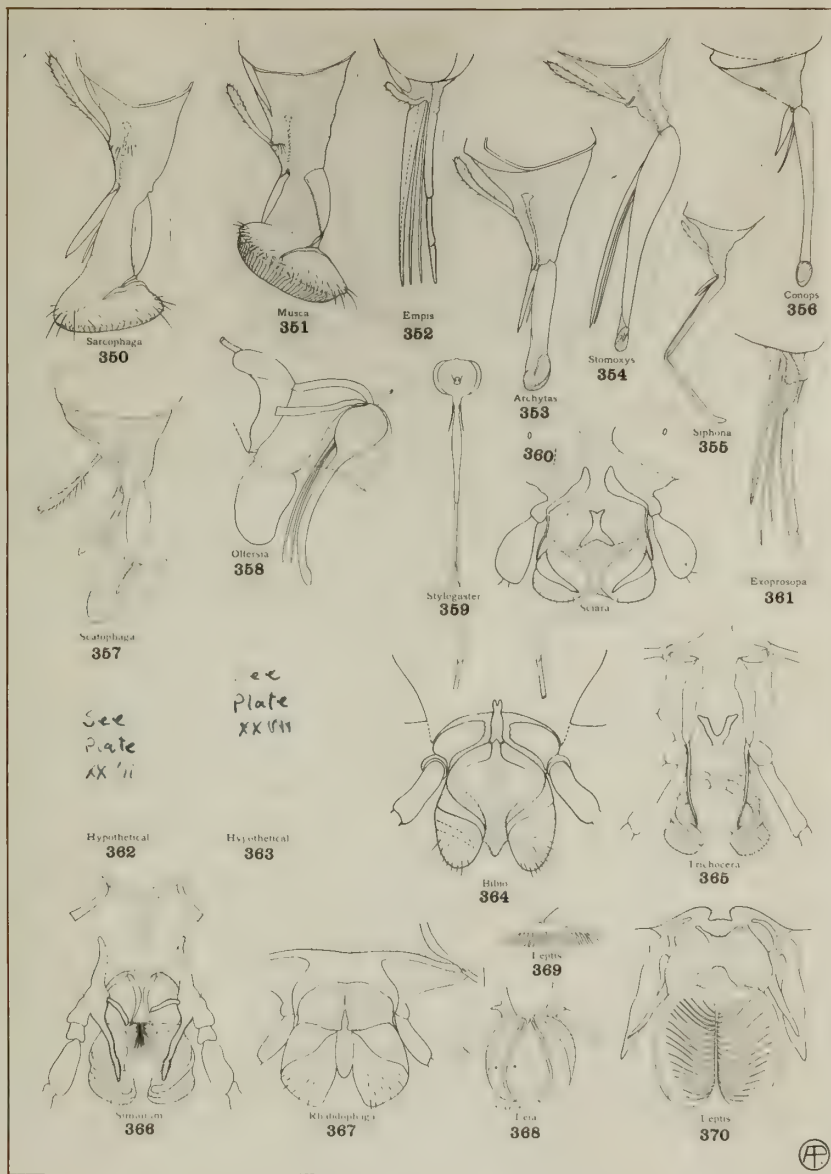


EXPLANATION OF PLATE XVI.

Mouth-parts.

- Fig. 350. *Sarcophaga haemorrhoidalis*, lateral aspect.
- Fig. 351. *Musca domestica*, lateral aspect.
- Fig. 352. *Empis clausa*, lateral aspect.
- Fig. 353. *Archytas analis*, lateral aspect.
- Fig. 354. *Stomoxys calcitrans*, lateral aspect.
- Fig. 355. *Siphona geniculata*, lateral aspect.
- Fig. 356. *Conops brachyrhynchus*, lateral aspect.
- Fig. 357. *Scatophaga furcata*, lateral aspect.
- Fig. 358. *Olfersia ardeae*, lateral aspect.
- Fig. 359. *Stylogaster biannulata*, caudal aspect.
- Fig. 360. *Sciara varians*, cephalic aspect of maxillae and labium.
- Fig. 361. *Exoprosopa fasciata*, lateral aspect.
- Fig. 362. Hypothetical Type,
- Fig. 363. Hypothetical Type,
- Fig. 364. *Bibio femoratus*, cephalic aspect, labium and maxillae.
- Fig. 365. *Trichocera bimacula*, cephalic view, of the labium and the maxillae.
- Fig. 366. *Simulium venustum*, cephalic aspect, labium and maxillae.
- Fig. 367. *Rhabdophaga strobiloides*, caudal aspect of the labium and the maxillae.
- Fig. 368. *Leia oblectabilis*, cephalic aspect.
- Fig. 369. *Leptis vertebrata*, mesal aspect of a glossa.
- Fig. 370. *Leptis vertebrata*, caudal aspect of the labium and the maxillae.

PLATE XVI.

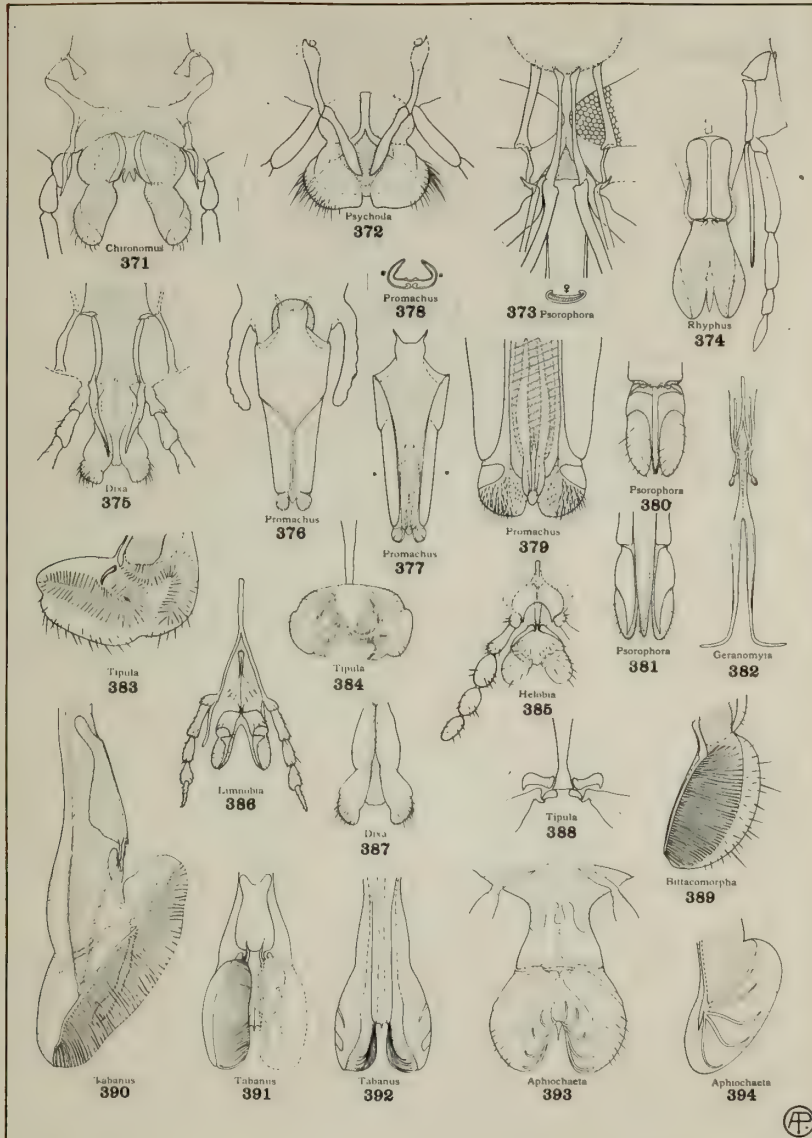


EXPLANATION OF PLATE XVII.

Labium and Maxillae.

- Fig. 371. *Chironomus ferrugineovittatus*, cephalic aspect.
- Fig. 372. *Psychoda albipennis*, cephalic aspect.
- Fig. 373. *Psorophora ciliata*, female, cephalic aspect, portion of mandibles, maxillae, labium and head-capsule.
- Fig. 374. *Rhyphus punctatus*, cephalic aspect.
- Fig. 375. *Dixa clavata*, cephalic aspect.
- Fig. 376. *Promachus vertebratus*, caudal aspect.
- Fig. 377. *Promachus vertebratus*, cephalic aspect of labium.
- Fig. 378. *Promachus vertebratus*, cross section of labium. Fig. 377.
- Fig. 379. *Promachus vertebratus*, enlarged cephalic aspect of labium.
- Fig. 380. *Psorophora*^a *ciliata*, caudal aspect of the distiproboscis.
- Fig. 381. *Psorophora ciliata*, cephalic aspect of distiproboscis.
- Fig. 382. *Geranomyia canadensis*, cephalic aspect.
- Fig. 383. *Tipula bicornis*, mesal aspect of distal end of labium.
- Fig. 384. *Tipula bicornis*, caudal aspect of labium.
- Fig. 385. *Helobia punctipennis*, caudal aspect.
- Fig. 386. *Limnobia immatura*, caudal aspect.
- Fig. 387. *Dixa clavata*, caudal aspect of labium.
- Fig. 388. *Tipula bicornis*, sclerites about distal end of mentum.
- Fig. 389. *Bittacomorpha clavipes*, mesal view of a labella.
- Fig. 390. *Tabanus giganteus*^e, mesal aspect of labium.
- Fig. 391. *Tabanus giganteus*^e, caudal aspect of labium.
- Fig. 392. *Tabanus giganteus*^e, cephalic aspect of labium.
- Fig. 393. *Aphiochaeta agarici*, caudal aspect.
- Fig. 394. *Aphiochaeta agarici*, mesal aspect of labella.

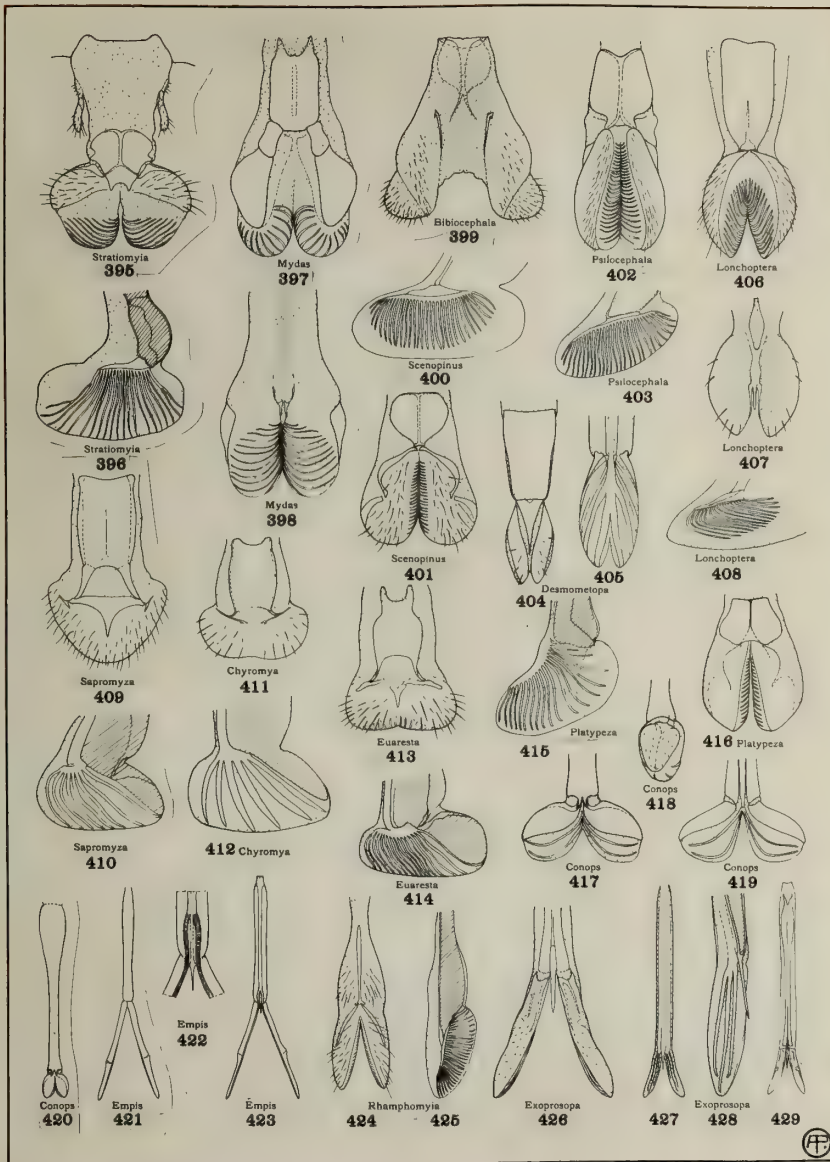
PLATE XVII.



EXPLANATION OF PLATE XVIII.

Labium.

- Fig. 395. *Stratiomyia apicula*, caudal aspect of mouth-parts.
Fig. 396. *Stratiomyia apicula*, mesal aspect.
Fig. 397. *Mydas clavatus*, caudal aspect of labium.
Fig. 398. *Mydas clavatus*, cephalic aspect.
Fig. 399. *Bibiocephala elegantula*, cephalic aspect.
Fig. 400. *Scenopinus fenestralis*, mesal aspect.
Fig. 401. *Scenopinus fenestralis*, caudal aspect.
Fig. 402. *Psilocephala haemorrhoidalis*, caudal aspect.
Fig. 403. *Psilocephala haemorrhoidalis*, mesal aspect.
Fig. 404. *Desmometopa latipes*, caudal aspect.
Fig. 405. *Desmometopa latipes*, cephalic aspect.
Fig. 406. *Lonchoptera lutea*, caudal aspect.
Fig. 407. *Lonchoptera lutea*, cephalic aspect.
Fig. 408. *Lonchoptera lutea*, mesal aspect.
Fig. 409. *Sapromyza vulgaris*, caudal aspect.
Fig. 410. *Sapromyza vulgaris*, mesal aspect.
Fig. 411. *Chyromya concolor*, caudal aspect.
Fig. 412. *Chyromya concolor*, mesal aspect.
Fig. 413. *Euaresta aequalis*, caudal aspect.
Fig. 414. *Euaresta aequalis*, mesal aspect.
Fig. 415. *Platypeza velutina*, mesal aspect.
Fig. 416. *Platypeza velutina*, caudal aspect.
Fig. 417. *Conops brachyrhynchus*, caudal aspect of distal end.
Fig. 418. *Conops brachyrhynchus*, lateral aspect of distal end.
Fig. 419. *Conops brachyrhynchus*, cephalic aspect of distal end.
Fig. 420. *Conops brachyrhynchus*, caudal aspect.
Fig. 421. *Empis clausa*, caudal aspect.
Fig. 422. *Empis clausa*, portion of cephalic aspect, enlarged.
Fig. 423. *Empis clausa*, cephalic aspect.
Fig. 424. *Rharnphomyia glabra*, caudal aspect.
Fig. 425. *Rharnphomyia glabra*, mesal aspect.
Fig. 426. *Exoprosopa fasciata*, caudal aspect of distal end.
Fig. 427. *Exoprosopa fasciata*, cephalic aspect.
Fig. 428. *Exoprosopa fasciata*, mesal aspect of distal end.
Fig. 429. *Exoprosopa fasciata*, caudal aspect.

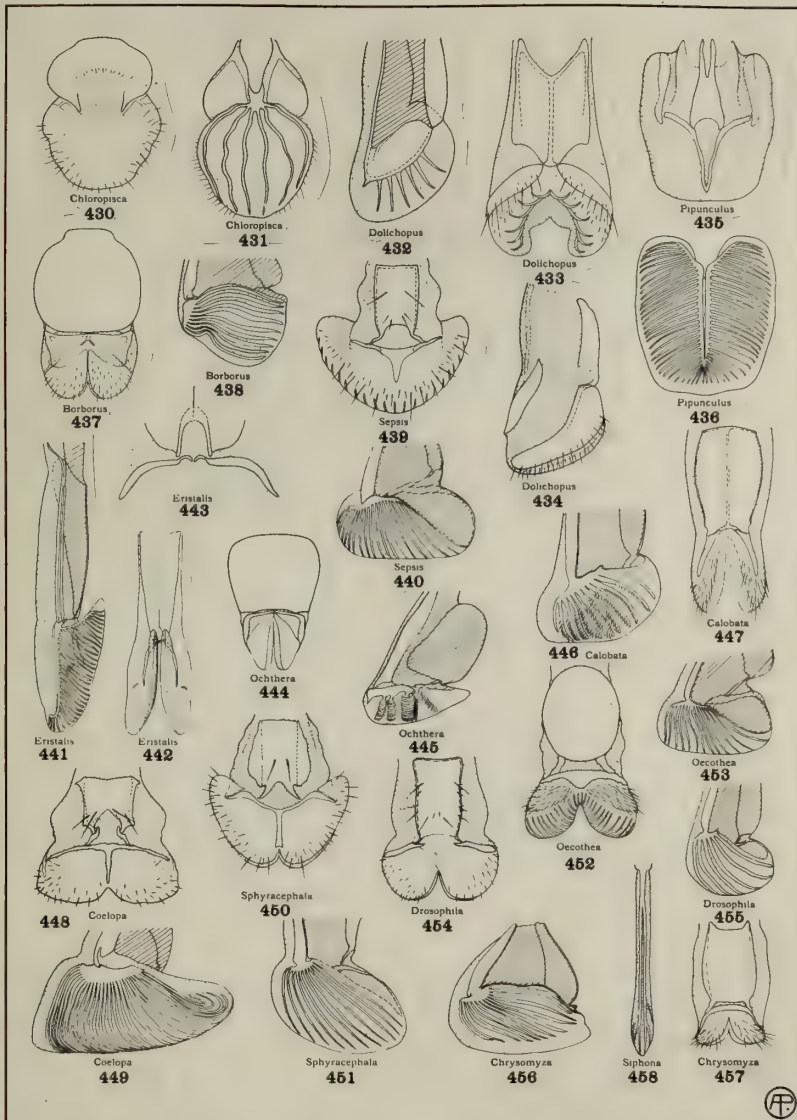


EXPLANATION OF PLATE XIX.

Labium.

- Fig. 430. *Chloropisca glabra*, caudal aspect.
Fig. 431. *Chloropisca glabra*, cephalic aspect.
Fig. 432. *Dolichopus bifractus*, mesal aspect.
Fig. 433. *Dolichopus bifractus*, caudal aspect.
Fig. 434. *Dolichopus bifractus*, lateral aspect.
Fig. 435. *Pipunculus cingulatus*, caudal aspect.
Fig. 436. *Pipunculus cingulatus*, cephalic aspect.
Fig. 437. *Borborus equinus*, caudal aspect.
Fig. 438. *Borborus equinus*, mesal aspect.
Fig. 439. *Sepsis violacea*, caudal aspect.
Fig. 440. *Sepsis violacea*, mesal aspect.
Fig. 441. *Eristalis tenax*, mesal aspect.
Fig. 442. *Eristalis tenax*, caudal view.
Fig. 443. *Eristalis tenax*, distal end of theca, caudal aspect.
Fig. 444. *Ochthera mantis*, caudal aspect.
Fig. 445. *Ochthera mantis*, mesal aspect.
Fig. 446. *Calobata univitta*, mesal aspect.
Fig. 447. *Calobata univitta*, caudal aspect.
Fig. 448. *Coelopa vanduzeei*, caudal aspect.
Fig. 449. *Coelopa vanduzeei*, mesal aspect.
Fig. 450. *Sphyr^acephala brevicornis*, caudal aspect.
Fig. 451. *Sphyracephala brevicornis*, mesal aspect.
Fig. 452. *Oecothoa fenestralis*, caudal aspect.
Fig. 453. *Oecothoa fenestralis*, mesal aspect.
Fig. 454. *Drosophila amelophila*, caudal aspect.
Fig. 455. *Drosophila amelophila*, mesal aspect.
Fig. 456. *Chrysomya demandata*, mesal aspect.
Fig. 457. *Chrysomya demandata*, caudal aspect.
Fig. 458. *Siphona geniculata*, cephalic aspect of distiproboscis.

PLATE XIX.

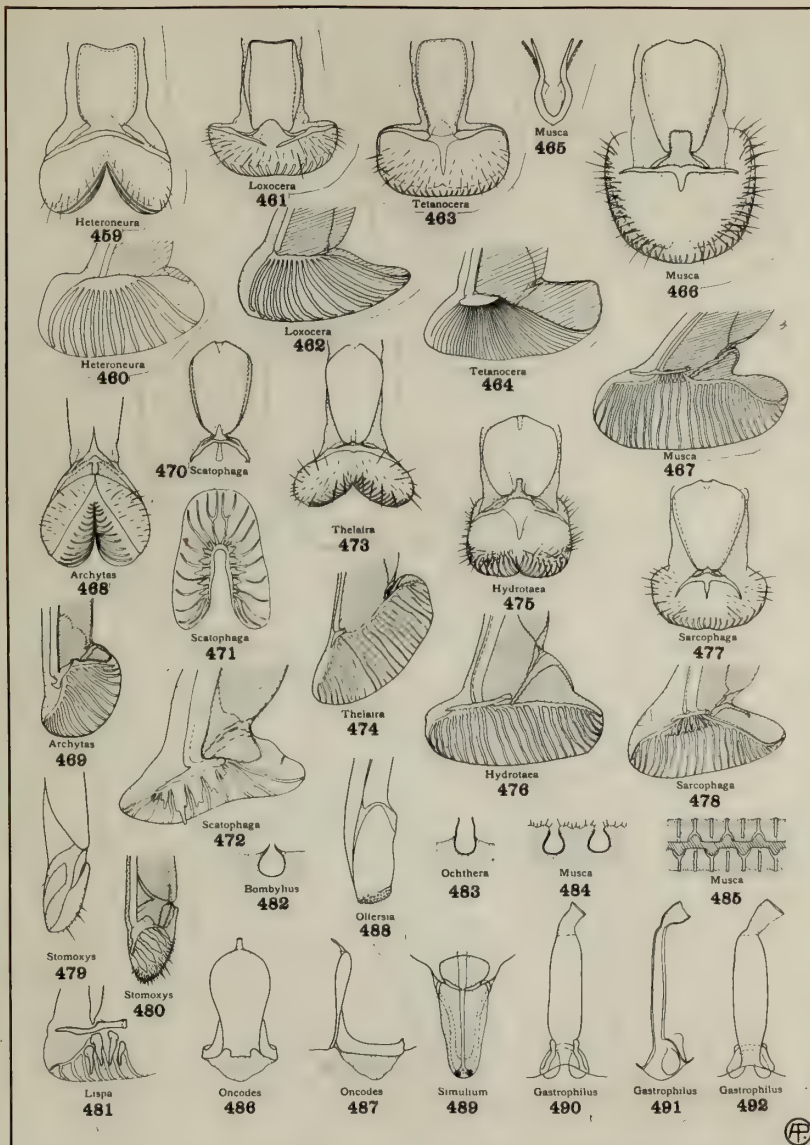


EXPLANATION OF PLATE XX.

Labium.

- Fig. 459. *Heteroneura flavifacies*, caudal aspect of labium.
- Fig. 460. *Heteroneura flavifacies*, mesal aspect of labium.
- Fig. 461. *Loxocera pectoralis*, caudal aspect of labium.
- Fig. 462. *Loxocera pectoralis*, mesal aspect of labium.
- Fig. 463. *Tetanocera plumosa*, caudal aspect of the labium.
- Fig. 464. *Tetanocera plumosa*, mesal aspect of the labium.
- Fig. 465. *Musca domestica*, dorsal aspect of the glossae.
- Fig. 466. *Musca domestica*, caudal aspect of the labium.
- Fig. 467. *Musca domestica*, mesal aspect of the labium.
- Fig. 468. *Archytas analis*, caudal aspect of the labium.
- Fig. 469. *Archytas analis*, mesal aspect of the labium.
- Fig. 470. *Scatophaga furcata*, caudal aspect of the mediproboscis.
- Fig. 471. *Scatophaga furcata*, ventral aspect of the labellae.
- Fig. 472. *Scatophaga furcata*, mesal aspect of the labium.
- Fig. 473. *Thelaira leucozona*, caudal aspect of the labium.
- Fig. 474. *Thelaira leucozona*, mesal aspect of the labium.
- Fig. 475. *Hydrotaea dentipes*, caudal aspect of the labium.
- Fig. 476. *Hydrotaea dentipes*, mesal aspect of the labium.
- Fig. 477. *Sarcophaga haemorrhoidalis*, caudal aspect of the labium.
- Fig. 478. *Sarcophaga haemorrhoidalis*, mesal aspect of the labium.
- Fig. 479. *Stomoxys calcitrans*, lateral view of distal end of labium.
- Fig. 480. *Stomoxys calcitrans*, mesal view of distal end of labium.
- Fig. 481. *Lispa nasoni*, lateral view of distal end of the labium.
- Fig. 482. *Bombylius major*, section thru pseudotrachea, "Dimmock".
- Fig. 483. *Ochthera mantis*, cross section of pseudotrachea.
- Fig. 484. *Musca domestica*, section thru pseudotracheae, "Dimmock".
- Fig. 485. *Musca domestica*, enlarged pseudotrachea, "Dimmock".
- Fig. 486. *Oncodes costatus*, entire mouth-parts, caudal aspect.
- Fig. 487. *Oncodes costatus*, entire mouth-parts, lateral aspect.
- Fig. 488. *Olfersia ardeae*, lateral view of distal end of labium.
- Fig. 489. *Simulium venustum*, cephalic aspect of the labrum.
- Fig. 490. *Castrophilus equi*, entire mouth-parts, caudal aspect.
- Fig. 491. *Castrophilus equi*, sagittal section thru mouth-parts.
- Fig. 492. *Castrophilus equi*, entire mouth-parts, cephalic aspect.

PLATE XX.



EXPLANATION OF PLATE XXI.

Epipharynx and Hypopharynx and Associated Parts.

- Fig. 493. Hypothetical Type, lateral aspect.
- Fig. 494. *Tabanus gigant^eus*, female, lateral aspect.
- Fig. 495. *Tabanus gigant^eus*, male, lateral aspect.
- Fig. 496. *Tabanus gigant^eus*, female, caudal aspect.
- Fig. 497. *Simulium venustum*, female, lateral aspect.
- Fig. 498. *Simulium venustum*, female, caudal aspect.
- Fig. 499. *Trichocera bimacula*, lateral aspect.
- Fig. 500. *Trichocera bimacula*, caudal aspect.
- Fig. 501. *Dixa clavata*, lateral aspect.
- Fig. 502. *Dixa clavata*, caudal aspect.
- Fig. 503. *Tipula bicornis*, lateral aspect.
- Fig. 504. *Psorophora ciliata*, female, lateral aspect.
- Fig. 505. *Psorophora ciliata*, female, caudal aspect.
- Fig. 506. *Geranomyia canadensis*, lateral aspect.
- Fig. 507. *Rhyphus punctatus*, lateral aspect.
- Fig. 508. *Rhyphus punctatus*, caudal aspect.

PLATE XXI.

see
Plate
XVII

Hypothetical
493



Tabanus ♀
494



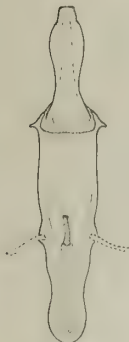
Tabanus ♂
495



Tabanus ♀
496



Simulium
497



Simulium
498



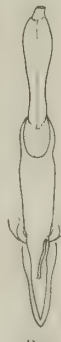
Trichocera
499



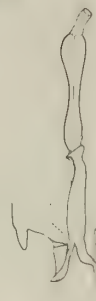
Trichocera
500



Dixia
501



Dixia
502



Tipula
503



Psorophora ♀
504



Psorophora
505



Geranomyia
506



Limnobia
507



Rhyphus
508



Rhyphus
509

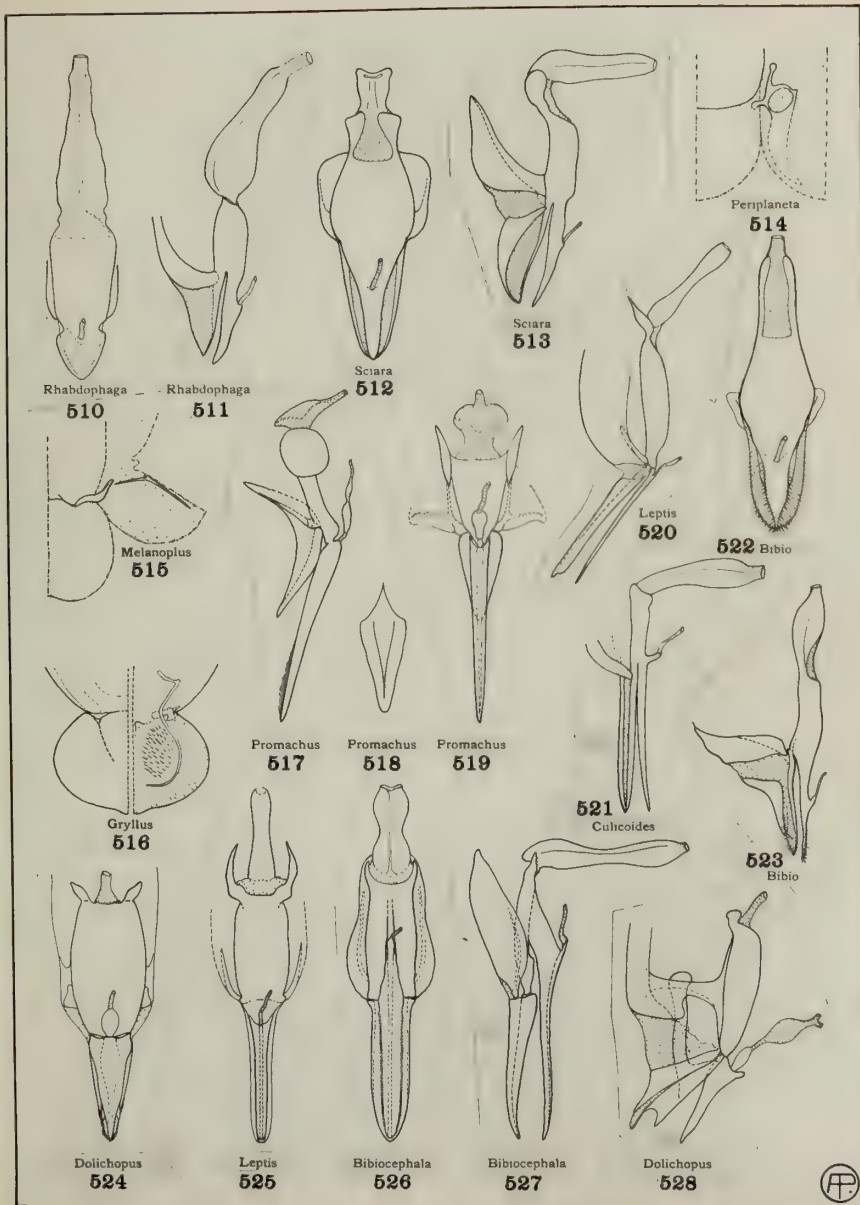


EXPLANATION OF PLATE XXII.

Epipharynx and Hypopharynx and Associated Parts.

- Fig. 510. *Rhabdophaga strobiloides*, caudal aspect.
- Fig. 511. *Rhabdophaga strobiloides*, lateral aspect.
- Fig. 512. *Sciara varians*, caudal aspect.
- Fig. 513. *Sciara varians*, lateral aspect.
- Fig. 514. *Periplaneta*, ental aspect of flattened-out clypeus, labrum and epipharynx.
- Fig. 515. *Melanoplus differentialis*, ental aspect of flattened-out clypeus, labrum and epipharynx.
- Fig. 516. *Gryllus pennsylvanicus*, cephalic and caudal aspects of the right-half of clypeus, labrum and epipharynx.
- Fig. 517. *Promachus vertebratus*, lateral aspect.
- Fig. 518. *Promachus vertebratus*, caudal aspect of epipharynx and labrum.
- Fig. 519. *Promachus vertebratus*, caudal aspect.
- Fig. 520. *Leptis vertebrata*, lateral aspect.
- Fig. 521. *Culicoides sanguisugus*, lateral aspect.
- Fig. 522. *Bibio femoratus*, caudal aspect.
- Fig. 523. *Bibio femoratus*, lateral aspect.
- Fig. 524. *Dolichopus bifractus*, caudal aspect.
- Fig. 525. *Leptis vertebrata*, caudal aspect.
- Fig. 526. *Bibiocephala elegantula*, caudal aspect.
- Fig. 527. *Bibiocephala elegantula*, lateral aspect.
- Fig. 528. *Dolichopus bifractus*, lateral aspect.

PLATE XXII.

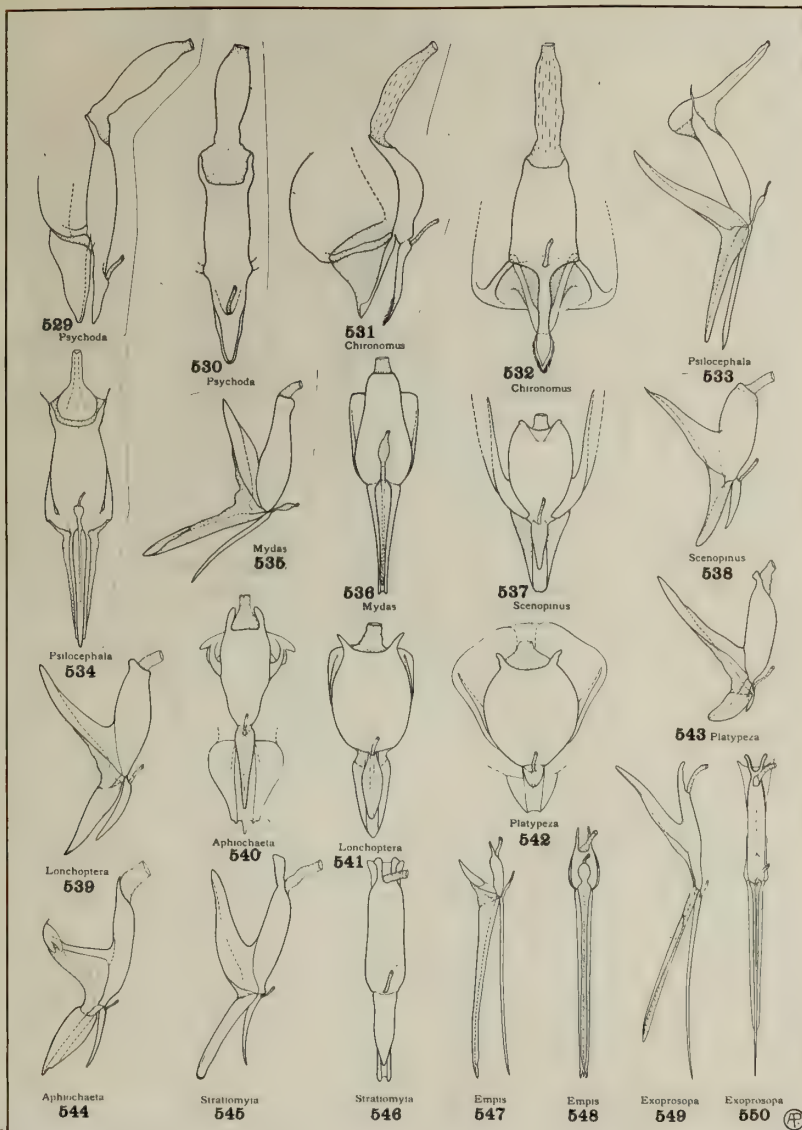


EXPLANATION OF PLATE XXIII.

Epipharynx and Hypopharynx and Associated Parts.

- Fig. 529. *Psychoda albipennis*, lateral aspect.
- Fig. 530. *Psychoda albipennis*, caudal aspect.
- Fig. 531. *Chironomus ferrugineovittatus*, lateral aspect.
- Fig. 532. *Chironomus ferrugineovittatus*, caudal aspect.
- Fig. 533. *Psilocephala haemorrhoidalis*, lateral aspect.
- Fig. 534. *Psilocephala haemorrhoidalis*, caudal aspect.
- Fig. 535. *Mydas clavatus*, lateral aspect.
- Fig. 536. *Mydas clavatus*, caudal aspect.
- Fig. 537. *Scenopinus fenestralis*, caudal aspect.
- Fig. 538. *Scenopinus fenestralis*, lateral aspect.
- Fig. 539. *Lonchoptera lutea*, lateral aspect.
- Fig. 540. *Aphiochaeta agarici*, caudal aspect.
- Fig. 541. *Lonchoptera lutea*, caudal aspect.
- Fig. 542. *Platypeza velutina*, caudal aspect.
- Fig. 543. *Platypeza velutina*, lateral aspect.
- Fig. 544. *Aphiochaeta agarici*, lateral aspect.
- Fig. 545. *Stratiomyia apicula*, lateral aspect.
- Fig. 546. *Stratiomyia apicula*, caudal aspect.
- Fig. 547. *Empis clausa*, lateral aspect.
- Fig. 548. *Empis clausa*, caudal aspect.
- Fig. 549. *Exoprosopa fasciata*, lateral aspect.
- Fig. 550. *Exoprosopa fasciata*, caudal aspect.

PLATE XXIII.

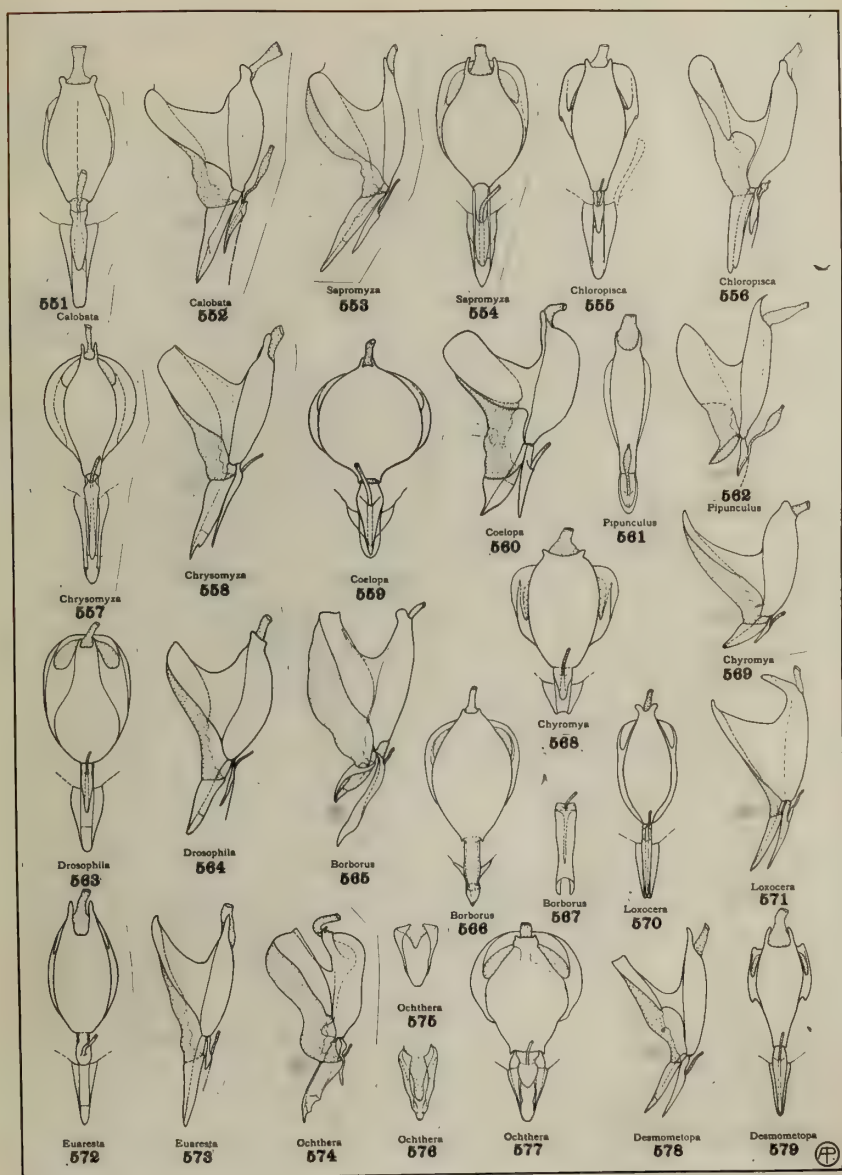


EXPLANATION OF PLATE XXIV.

Epipharynx and Hypopharynx and Associated Parts.

- Fig. 551. *Calobata univitta*, caudal aspect.
- Fig. 552. *Calobata univitta*, lateral aspect.
- Fig. 553. *Sapromyza vulgaris*, lateral aspect.
- Fig. 554. *Sapromyza vulgaris*, caudal aspect.
- Fig. 555. *Chloropisca glabra*, caudal aspect.
- Fig. 556. *Chloropisca glabra*, lateral aspect.
- Fig. 557. *Chrysomya demandata*, caudal aspect.
- Fig. 558. *Chrysomya demandata*, lateral aspect.
- Fig. 559. *Coelopa vanduzeei*, caudal aspect.
- Fig. 560. *Coelopa vanduzeei*, lateral aspect.
- Fig. 561. *Pipunculus cingulatus*, caudal aspect.
- Fig. 562. *Pipunculus cingulatus*, lateral aspect.
- Fig. 563. *Drosophila* ^p~~amel~~ophila, caudal aspect.
- Fig. 564. *Drosophila* ^p~~amel~~ophila, lateral aspect.
- Fig. 565. *Borborus equinus*, lateral aspect.
- Fig. 566. *Borborus equinus*, caudal aspect.
- Fig. 567. *Borborus equinus*, caudal aspect of the hypopharynx
united with the cephalic aspect of the labium.
- Fig. 568. *Chyromya concolor*, caudal aspect.
- Fig. 569. *Chyromya concolor*, lateral aspect.
- Fig. 570. *Loxocera pectoralis*, caudal aspect.
- Fig. 571. *Loxocera pectoralis*, lateral aspect.
- Fig. 572. *Euaresta aequalis*, caudal aspect.
- Fig. 573. *Euaresta aequalis*, lateral aspect.
- Fig. 574. *Ochthera mantis*, lateral aspect.
- Fig. 575. *Ochthera mantis*, caudal aspect of the labrum
- Fig. 576. *Ochthera mantis*, caudal aspect of the epipharynx.
- Fig. 577. *Ochthera mantis*, caudal aspect.
- Fig. 578. *Desmometopa latipes*, lateral aspect.
- Fig. 579. *Desmometopa latipes*, caudal aspect.

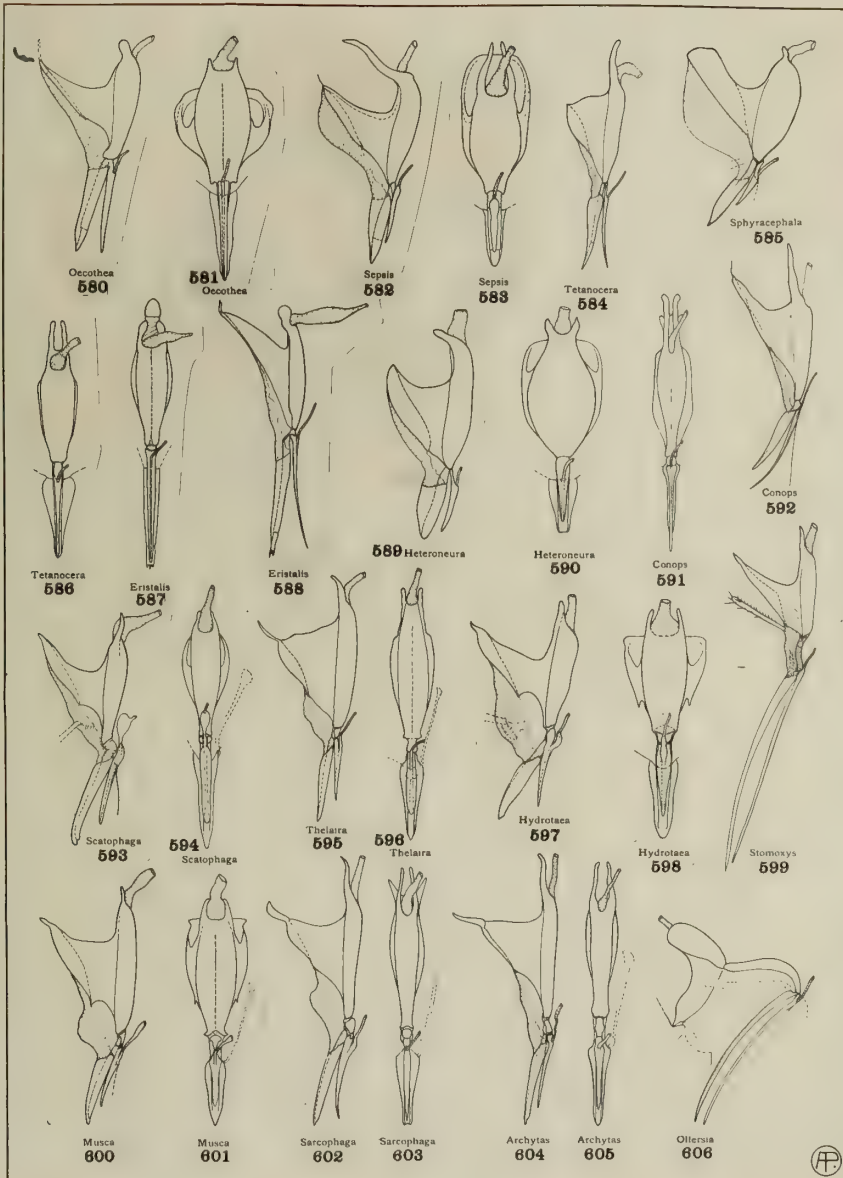
PLATE XXIV.



EXPLANATION OF PLATE XXV.

Epipharynx and Hypopharynx and Associated Parts.

- Fig. 580. *Oecóthea fenestralis*, lateral aspect.
Fig. 581. *Oecothea fenestralis*, caudal aspect.
Fig. 582. *Sepsis violacea*, lateral aspect.
Fig. 583. *Sepsis violacea*, caudal aspect.
Fig. 584. *Tetanocera plumosa*, lateral aspect.
Fig. 586. *Tetanocera plumosa*, caudal aspect.
Fig. 585. *Sphyracephala brevicornis*, lateral aspect.
Fig. 587. *Eristalis tenax*, caudal aspect.
Fig. 588. *Eristalis tenax*, lateral aspect.
Fig. 589. *Heteroneura flavifacies*, lateral aspect.
Fig. 590. *Heteroneura flavifacies*, caudal aspect.
Fig. 591. *Conops brachyrhynchus*, caudal aspect.
Fig. 592. *Conops brachyrhynchus*, lateral aspect.
Fig. 593. *Scatophaga furcata*, lateral aspect.
Fig. 594. *Scatophaga furcata*, caudal aspect.
Fig. 595. *Thelaira leucozona*, lateral aspect.
Fig. 596. *Thelaira leucozona*, caudal aspect.
Fig. 597. *Hydrotaea dentipes*, lateral aspect.
Fig. 598. *Hydrotaea dentipes*, caudal aspect.
Fig. 599. *Stomoxys calcitrans*, lateral aspect.
Fig. 600. *Musca domestica*, lateral aspect.
Fig. 601. *Musca domestica*, caudal aspect.
Fig. 602. *Sarcophaga haemorrhoidalis*, lateral aspect.
Fig. 603. *Sarcophaga haemorrhoidalis*, caudal aspect.
Fig. 604. *Archytas analis*, lateral aspect.
Fig. 605. *Archytas analis*, caudal aspect.
Fig. 606. *Olfersia ardeae*, lateral aspect.



EXPLANATION OF PLATE XXVI.

Fig. 1. Hypothetical head, cephalic aspect.

Fig. 73. Hypothetical head, caudal aspect.

Fig. 140. Hypothetical head, lateral aspect.

Fig. 141. Hypothetical tentorium, mesal aspect of right
half.

Fig. 607. *Mycetophila punctata*, cephalic aspect of head.



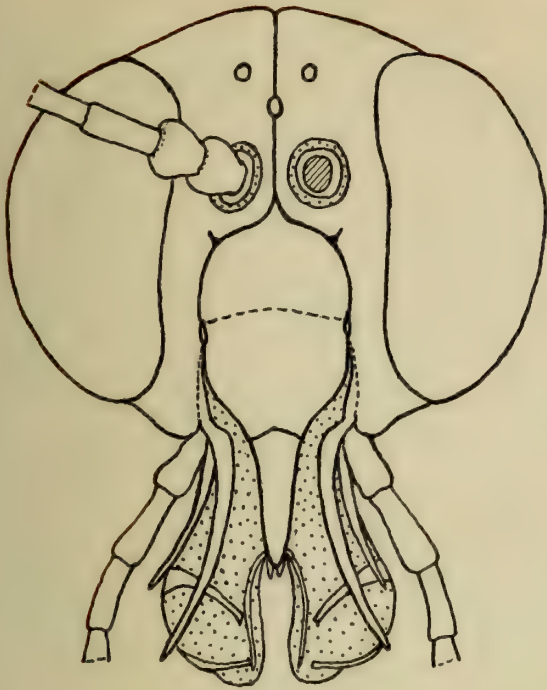


Fig. 1.

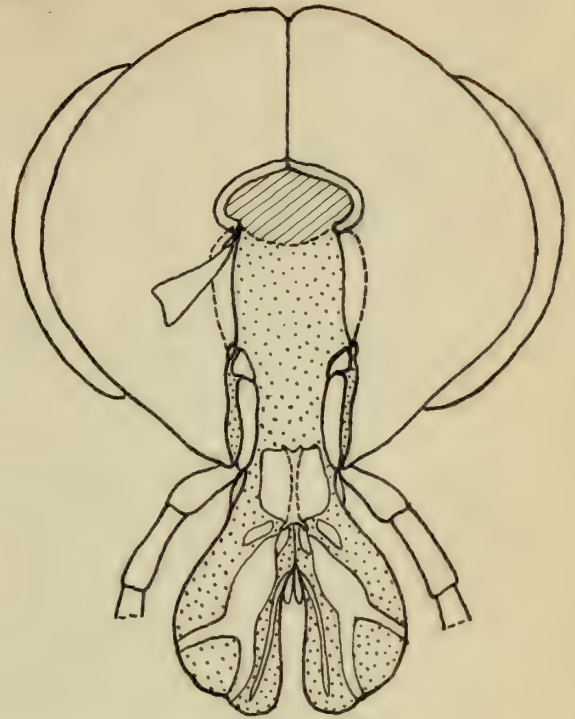


Fig. 73.

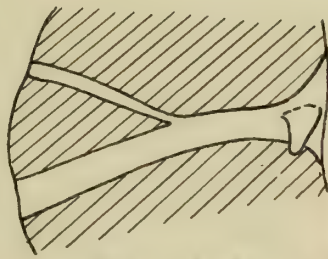


Fig. 141.



Fig. 140.

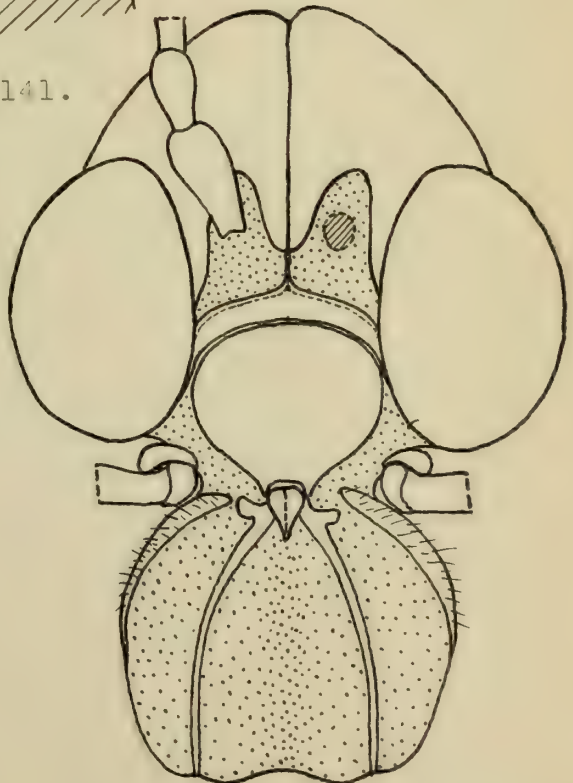


Fig. 607.
Mycetophila.

EXPLANATION OF PLATE XXVII.

Fig. 257. Hypothetical maxilla, caudal aspect.

Fig. 362. Typical labium, section thru meson.

Fig. 363. Hypothetical proboscis, lateral aspect.

Fig. 493. Hypothetical epipharynx and hypopharynx.

Fig. 606. Hypothetical mandible.

Fig. 609. Hypothetical antenna.

HYPOTHETICAL TYPES.

PLATE XXVII.

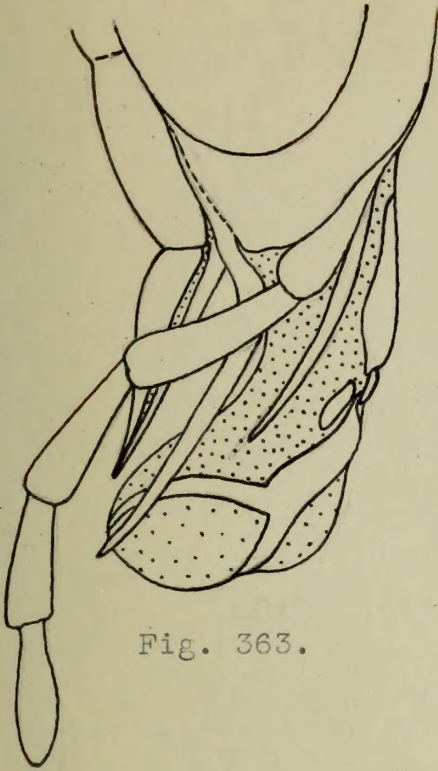


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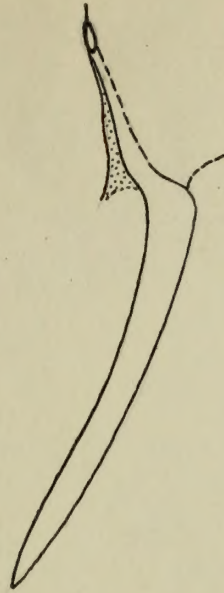


Fig. 608.

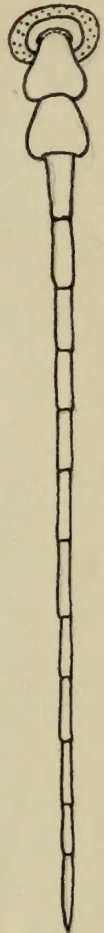


Fig. 609.

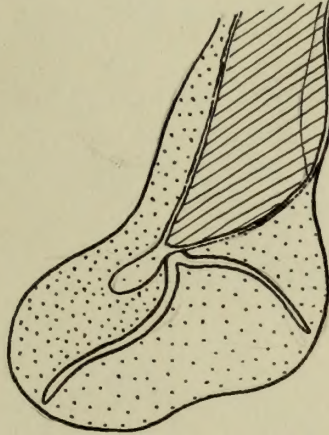


Fig. 362.



Fig. 257.

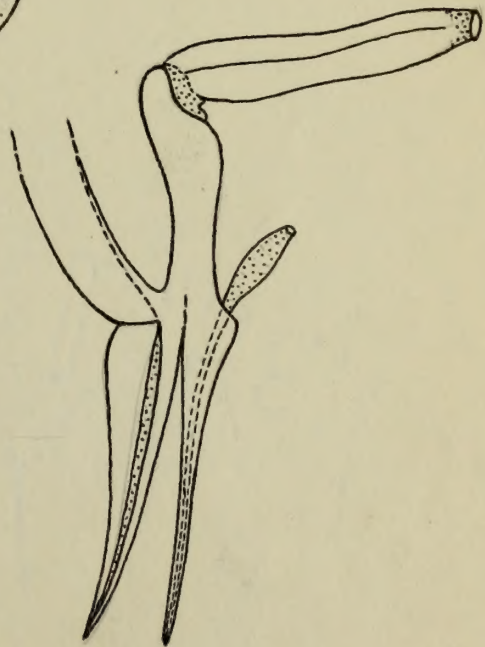


Fig. 493

~~PLATE XLIX.~~

